THE

ELECTRICAL REVIEW.

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INDIA-RUBBER INSULATION.

EXTENSIVE as is the network of submarine cables which now interlaces the surface of the globe, there is no indication that the completion of the same is within measurable distance. It would, perhaps, be difficult to point out in what direction extensive developments of submarine telegraphy may be expected, but that the progress in the future will be slow is hardly probable; hence the question of what is to be the type of the future cable may afford reasonable grounds for speculation. We do not intend here to discuss the question whether the present form of cable is likely to prove, in the course of a few years, to be an obsolete one, as Prof. Silvanus Thompson imagines it will, and with good show of reason, but we would consider what is likely to be the future as regards the nature of the insulating material to be used for cable purposes. The knell of gutta-percha has, in the opinion of some, been sounded; but the fate of this material is probably not so near as many wiseacres have predicted, for we can call to mind more than one instance, dating back at least a decade, in which we were informed with great assurance that five years would see an end to the use of the material, and yet at the present time we see cable after cable being turned out from the manufacturers' works, and still of the same tried composition. Nevertheless, there are not wanting plain indications that there must be a limit to the supply of gutta-percha, and pending the cultivation to maturity of gutta-percha trees, a matter which may possibly be taken in hand, it behoves us to be ready with a substitute which can be obtained in quantities commensurate with the demands which may be made for it. Leaving aside the possibilities of paper and other substances coming to the fore (and it is quite on the cards that they will), at the present time there is no material which offers so much promise as India-rubber. The history of this substance for use in submarine telegraphy has been, as all telegraph engineers know, a chequered one. Many disastrous failures resulting from its use seriously shook public confidence in it, and the uniform success which gutta-percha gave naturally resulted in the preference being given to the latter, and were it not that the supply of the gum threatens to give out, it is more than probable that India-rubber would, as an insulator in submarine telegraphy, still be left in the background. Now, however, that the question must be faced, what are the actual facts as regards India-rubber. Much will be learned by a perusal of the article on "Hooper's Core for Submarine Cables," which we give elsewhere. That India-rubber can be depended upon is, we think, amply proved by the facts there set forth. It hardly requires to be said that a guarantee to maintain a cable with an India-rubber core for a period of 12 years was a risk which no manufacturer would undertake, were he not absolutely certain that the material could be relied upon for durability. The success of the experiment (if we may call

it such), is one upon which we most heartily congratulate Mr. J. P. Hooper, and is one which is not unlikely to restore confidence in, and to extend the use of, rubber.

It is, perhaps, almost unnecessary to restate what has often been pointed out, viz., that the supply of India-rubber, unlike that of gutta-percha, is almost unlimited. Gutta-percha trees take many years to come to maturity, and unless they are "bled to death," afford but a comparatively small supply of the substance. This is not the case with India-rubber; these trees are more widely spread, grow rapidly, and afford an abundant and continual supply of the gum, and the "milking" process is not an injurious one. It might be imagined that the failure of rubber to give satisfaction in the earlier days of submarine telegraphy was due to a great extent to unskilful manufacture. This, however, is not the case, as the processes by which the late Mr. Hooper made rubber to be a practical insulator, though now comparatively ancient history, are still the processes of the present day, and leave nothing to be desired; what failures took place were due to imperfection in mechanical details. With reference to this, it should be pointed out that when Hooper's rubber was introduced as a competitor to gutta-percha, the price of the latter was not what it subsequently became, and consequently a cable with a rubber core could not be produced at a remunerative price unless the weight of rubber used in proportion to the copper of the conductor was much less than that in the case of gutta-percha. It seems highly probable, therefore, that in this respect a mistake was made, and that for mechanical reasons, if more rubber had been used, better success would have been obtained. That rubber still gives satisfaction is proved by the fact that the Cuba Submarine Company continue to specify for the material (Hooper's) for their extensions. What, it may be asked, are the special advantages of rubber for submarine cable insulation, seeing that from the point of working speed it possesses no advantage over gutta-percha; and seeing that as regards price it (at present) also presents no marked advantage. It is, we believe, a fact, though not a well-known one, that the high insulation of the rubber, and the nature of its substance, renders the detection of faults of manufacture a much easier and more certain matter than is the case with gutta-percha, and that consequently a submarine cable with rubber insulation, if it has passed the ordeal of the manufacturer's tests, may be absolutely relied upon not to develop faults when laid, excepting, of course, faults due to mechanical injury taking place after submersion. Again, rubber, unlike gutta-percha, is not attacked, except on the surface, by the teredo worm; consequently the expense of protecting brass tape is unnecessary. The fact that it will bear uninjured a high temperature is an important point in connection with its use in hot climates, the usual precautions of keeping the temperature down before the cable is laid, and when being laid, being in this respect unnecessary. Moreover, contrary to what is generally understood to be the case, the process of jointing is easy and certain; joints which have been made in a very indifferent manner by unskilled workmen have been found to be perfectly efficient and durable; and although the complete process of making a joint is a comparatively long one, it does not require the same amount of skill that is required in gutta-percha. At the same time, rubber core is not suitable for conditions of alternate wet and dry, unless well protected; it has failed when used as the leading-in shore-ends of cables; but inasmuch as it can be readily jointed to gutta-percha, this is not a point of importance in the case of submarine cables. For electric light leads the use of India-rubber is accepted as a matter of course, no one doubts its suitability for the purpose, and the fact that other materials are used is solely due to financial considerations. For submarine cable work, an insulator other than either gutta-percha or India-rubber would hardly be entertained, and there does not seem much probability for some time to come of the two gums in question having any serious rivals. Let the rubber manufacturers, therefore, show that they can fairly compete in price with the hitherto more popular gum, and they will have matters all their own way.

ELECTRIC CONDUITS.

AMONGST the papers read before the International Electrical Congress is one entitled "Underground Wires for Electric Lighting and Power Distribution," by Prof. Jackson, which describes the several systems of conduits most generally employed for underground cables in America, and from which it will be seen that American and English practice differ considerably. In England, as is well known, cast-iron, or less frequently, wrought-iron pipes and Callender-Webber casing are practically the only types of conduits used on a large scale for insulated cables, whilst it would appear from Prof. Jackson's paper that the two which meet with most favour here, viz., cast-iron pipes and Callender-Webber casing, do not occupy a position in the front rank amongst conduits in America, this place being occupied by wrought-iron pipes laid in concrete, cement lined sheet-iron pipes, glazed terra-cotta pipes, or rather conduits, each containing a number of rectangular ducts, and wood conduits.

Earthenware conduits of various types have been proposed and occasionally used in England, but owing to their liability to fracture, and the difficulty of making a joint sufficiently flexible to withstand without harm the effects of a sinking of the ground, they have not been often employed. Prof. Jackson recommends that the conduit should be laid in a bed of concrete, from 2 to 6 inches deep, and covered with a layer of the same material, in which case it may be laid with its top about 2 feet below the pavement; but if not laid in concrete, this depth should be increased to 3 feet.

With regard to the two types of iron pipe, Prof. Jackson says that the cement-lined sheet-iron pipe has the advantage of being lighter, cheaper and more durable than the wrought-iron pipe, whilst the great advantage of this latter over all other forms of conduit is its flexibility. In this respect it would appear that American engineers are more exacting than we are, besides being much bolder, as we read that experience in New York and Chicago proves that cables can be pulled easily around several bends with radii of 3 feet or less. We believe there are some sharp curves in the pipes laid by the City of London Electric Light Company, and it would be interesting to have the results of their experience, as it seems to us that several bends with radii of 3 feet must subject the cables to strains which cannot but be harmful to them, and that such bends should, therefore, be avoided at all costs.

The paper concludes with some notes on manholes, and the necessity of draining them, and of keeping them free from gas, either by means of blowers as used in New York, or by connecting them to hollow electric light poles which act as ventilating shafts, and forms a valuable addition to the existing literature on the subject of underground work as practised in America.

Incandescent Lamps of Low Power.

WE think that at the present time there is not enough consideration given to the economical use of incandescent lamps. It is no uncommon thing to find users of electric light arranging lamps of large candle-power in the most lavish manner and with an utter disregard to the electric lighting bill. As a matter of fact, there are very few instances in which an 8 C.P. lamp could not replace one of 16 C.P. in a satisfactory manner, and in many cases a 5 C.P. lamp would give all the light required. To our knowledge 16 C.P. lamps are used on stairs, in passages, and sundry other places where the minimum amount of light is needed. We do not favour the dim and religious light for ordinary purposes, but we certainly think there is room for a more economical arrangement of lamps than at present exists. It is noticeable that where lamps are used for decorative purposes, they are of large size, yet the scheme of decorations would be considered incomplete if they did not include careful draping of the lamps, which has the effect of excluding the greater portion of the light. Hotels which are lighted by electricity have very often 16 C.P. lamps in small bedrooms, and while one cannot help admitting the brilliant effect produced, the waste is regretable. It must be remembered that in hotel bedrooms electricity is generally replacing the candle, and a 5 C.P. incandescent lamp would give seven or eight times as much light. We offer these suggestions for what they are worth, they have not the merit of originality, for Mr. Crompton, and other users of electric light in the household, have been long convinced of the economies to be affected by a careful consideration of the disposal of lamps.

The Treatment of Stricture of the Urethra by Electricity.

AN interesting article on this subject, by Dr. C. Mansell Moullin, has recently appeared in the *Lancet*. He says :—"The treatment of stricture of the urethra by the application of weak electric currents seems to have lost rather than to have gained favour during the past few years. The majority of the profession do not practice it; many of those who tried it at first have given it up, partly, perhaps, on account of the elaborate apparatus required, but chiefly because they do not find in it any great advantage over other methods; a few are still enthusiastic in its support. The statements made about it at first were too favourable, and now it is suffering from a natural reaction." A statement of his own experience with such treatment follows, but the author acknowledges that it does not embrace a very large number of completed cases. Early in this experience he formed the conclusion, in which, we believe, even the enthusiasts above referred to fully agree, that electrical treatment is not suited to all cases indiscriminately. In simple cicatricial strictures it was found that the effect "was closely similar to that which follows the tying in of a catheter, only it was more rapid." But, in spite of this, he "could not find that the passage of a weak electric current for half-an-hour on some half-a-dozen, or, perhaps, a dozen occasions, with intervals of several days between, effected any change in the character of the scar." Dr. Moullin says he used a current of 2 or 3 milliampères, in some cases, and 8 to 10 in others, but he does not state which pole he attached to the bougie, nor where the other electrode was placed, or what was its size and form. These are points of considerable importance. No doubt readers of the *Lancet* are expected to assume that the bougie carried the negative pole, but the omission to mention the position of the positive is to be regretted, as it is quite possible that the course of the current and its concentration, or lack of concentration, where most needed, had direct influence upon the results obtained. With strictures resulting from chronic inflammation the author had slightly better success, for he says, "I am inclined to think that these strictures were benefited to some extent by electricity." In some cases, with 5 milliampères of current, "it was my impression that the stricture tissue softened and yielded with more rapidity than usual." He found, however, that this result was only temporary, for "when the application ceases, or very soon afterwards, the effect ceases too, and the tissues resume their former character." "Electricity will succeed if thorough dilatation or division is practised at the same time; the urethra then is given a sufficiently long period of perfect physiological rest, and absorption becomes possible; but without one or other of these the effect that it produces is only transient." A little further on, in speaking of the effect electricity has upon muscular spasm and congestion, Dr. Moullin says, "A weak current was used in the ordinary way, with the negative electrode in the urethra, and the resistance certainly yielded before it; but how far this was due to the electricity, and how far to the steady pressure of the instrument tiring the muscle out, it is impossible to say; my own impression is that the latter was quite as important as the former." His conclusions are summarised as follows: "In certain instances—those, for example, in which there is an indurated mass involving the urethra, with a very narrow, and perhaps tortuous, channel through it—electricity may be of some use; it assists in softening the dense tissue and so renders more easy the application of more effective methods, and it may, perhaps, relieve muscular spasm to some extent. I have not been able to find any proof that it is capable of doing more than this."

The Installation of New Buildings.

PEOPLE of wealth were never more eager than they are at the present day for appliances and methods which will add to the agreeableness and enjoyment of life; and people of moderate affluence as well as those of average means are equally anxious for inventions that will, without heightened cost, increase the amount of service they receive whilst reducing their establishment of servants. Architects who wish to keep pace with the times, must recognise these facts and allow them to influence their designs. How frequently we notice a handsome block of offices run up, and within a few weeks or months of its completion the place is being "pulled to pieces" for the introduction of electric communication and lighting wires. Is it cheaper to permit these inroads upon our comfort and convenience than to provide the necessary fittings during the erection of the building? By no ingenious manipulation of figures can an affirmative answer to this question be proved. The short-sightedness of people who are about to build is continually causing needless expense in this direction to themselves, and is delaying somewhat the more universal adoption of electricity. The architect too is a sufferer, for, as an American contemporary puts it: "The architect, who in this age of new and successful electrical invention, has no conduits in his plans for the electric communications, is simply caught napping; and his professional brethren in touch and sympathy with the latest developments in the arts and sciences, arrive while he is left." Electricity is really the architect's friend. By means of it he can at one stroke provide for exigencies which otherwise would perplex and harass him. It ought to be more widely recognised that, whilst provision for electrical conveniences in the original plans may mean a slightly increased "first cost," it is more than compensated for by the absence of annoyance, the continuity of the service, the avoidance of small bills for repairs, &c., which frequently play such a prominent part in the maintenance of an installation put into a building after the building has been finished.

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MECHANICAL THEORY OF LIGHT.

THE elastic solid theory, then, has failed; but are we therefore without any mechanical theory of light? Are we again reduced to merely writing down our equations, and calling some quantity which appears in them the amplitude of the light vibration, and the square of that quantity the intensity of the light? Or can we take a further step? Let us inquire what the properties of the ether must be which will lead us by strict reasoning to those equations which we know represent the laws of the propagation of light. These equations resemble in many respects those of an elastic solid. Let us, then, for a moment identify the displacement in a light-wave with an actual displacement of a molecule of some medium having properties resembling that of a solid. Then this medium must have rigidity or quasi-rigidity in order that it may transmit transverse waves; at the same time it must be incapable of transmitting normal waves, and this involves the supposition that the quantity, A, which appears in Green's equations, must vanish or be infinite. To suppose it infinite is to recur to the incompressible solid theory; we will assume, therefore, that it is zero. Reflection and refraction show us that the ether in a transparent medium such as glass differs in properties from that in air. It may differ either (1) in density or effective density, or (2) in rigidity or effective rigidity. The laws of double refraction and the phenomena of the scattering of light by small particles show us that the difference is, in the main, in density or effective density; the rigidity of the ether does not greatly vary in different media. Dispersion, absorption, and anomalous dispersion all tell us that in some cases energy is absorbed from the light vibrations by the matter through which they pass, or, to be more general, by something very intimately connected with the matter. We do not know sufficient to say what that action must be; we can, however, try the consequences of various hypotheses. Guided by the analogy of the motion of a solid in a fluid, let us assume that the action is proportional to the acceleration of the ether particles relative to the matter, and, further, that under certain circumstances, some of the energy of the ether particles is transferred to the matter, thus setting them in vibration. If such action be assumed, the actual density of the ether may be the same in all media, the mathematical expression for the forces will lead to the same equations as those we obtain by supposing that there is a variation of density, and since it is clearly reasonable to suppose that this action between matter and ether is, in a crystal, a function of the direction of vibration, the apparent or effective density of ether in such a body will depend on the direction of displacement. Now, these hypotheses will conduct us by strict mathematical reasoning to laws for the propagation, reflection, and refraction, double refraction and polarisation, dispersion, absorption, and anomalous dispersion and aberration of light which are in complete accordance with the most accurate experiments. The rotatory polarisation of quartz, sugar, and other substances points to a more complicated action between the ether and matter than is contemplated above; and, accordingly, other terms have to be introduced into the equations to account for these effects. It will be noted as a defect, and perhaps a fatal one, that the connection between electricity and light is not hinted at, but I hope to return to that point shortly.

Such a medium as I have described is afforded us by the labile ether of Lord Kelvin. It is an elastic solid, or quasi-solid, incapable of transmitting normal waves. The quantity, A, is zero, but Lord Kelvin has shown that the medium would still be stable provided its boundaries are fixed, or, which comes to the same thing, provided it extends to infinity. Such a medium would collapse if it were not held fixed at its boundaries; but if it be held fixed, and if then all points on any closed spherical surface in the medium receive a small normal displacement, so that the matter within the surface is compressed into a smaller volume, there will be no tendency either to aid or to prevent this compression, the medium in its new state will still be in equilibrium, the stresses in any portion of it which remains unaltered in shape are independent of its volume, and are functions only of the rigidity, and, implicitly, of the forces which hold the boundary of the whole medium fixed. A soap film affords in two dimensions an illustration of such a medium; the tension at any point of the film does not depend on the dimensions; we may suppose the film altered in area in any way we please—so long as it remains continuous—without changing the tension. Waves of displacement parallel to the surface of the film would not be transmitted. But such a film in consequence of its tension has an apparent rigidity for displacements normal to its surface; it can transmit transverse waves with a velocity which depends on the tension. Now the labile ether has a medium which has, in three dimensions, characteristics resembling those of the two-dimensional film. Its fundamental property is that the potential energy per unit volume, in an isotropic body, so far as it arises from a given strain, is proportional to the square of the resultant twist. In an incompressible elastic ether this potential energy depends upon the shearing strain. Given such a medium—and there is nothing impossible in its conception—the main phenomena of light follow as a necessary consequence. We have a mechanical theory by the aid of which we can explain the phenomena; we can go a few steps behind the symbols we use in our mathematical processes. Lord Kelvin, again, has shown us how such a medium might be made up of molecules having rotation in such a way that it could not be distinguished from an ordinary fluid in respect to any irrotational motion; it would, however, resist rotational movements with a force proportional to the twist, just the force required; the medium has no real rigidity, but only a quasi-rigidity conferred on it by its rotational motion. The actual periodic displacements of such a medium may constitute light. We may claim, then, with some confidence to have a mechanical theory of light. But now-a-days the ether has other functions to perform, and there is another theory to consider, which at present holds the field. Maxwell's equations of the electromagnetic field are practically identical with those of the quasi-labile ether. The symbols which occur can have an electro-magnetic meaning. We speak of permeability and inductive capacity instead of rigidity and density, and take as our variables the electric or magnetic displacements instead of the actual displacement or the rotation.

* Abstract of address delivered in Section A.

THE ELECTRO-MAGNETIC FIELD.

Still, such a theory is not mechanical. Electric force acts on matter charged with electricity, and the ratio of the force to the charge can be measured in mechanical units. A fundamental conception in Maxwell's theory is electric displacement, and this is proportional to the electric force. Moreover, its convergence measures the quantity of electricity present per unit volume; but we have no certain mechanical conception of electric displacement on quantity of electricity; we have no satisfactory mechanical theory of the electro-magnetic field. The first edition of the "Electricity and Magnetism" appeared 20 years ago. In it Maxwell says: "It must be carefully borne in mind that we have made only one step in the theory of the action of the medium. We have supposed it to be in a state of stress, but we have not in any way accounted for this stress, or explained how it is maintained. This step, however, appears to me to be an important one, as it explains by the action of consecutive parts of the medium phenomena, which were formerly supposed to be explicable only by direct action at a distance. I have not been able to make the next step—namely, to account by mechanical considerations for these stresses in the dielectric." And these words are true still. But, for all this, I think it may be useful to press the theory of the quasi-labile ether as far as it will go, and endeavour to see what the consequences must be. The analogy between the equations of the electro-magnetic field and those of an elastic solid has been discussed by many writers. In a most interesting paper on the theory of dimensions, read recently before the Physical Society, Mr. Williams has called attention to the fact that two only of these analogies have throughout a simple mechanical interpretation. These two have been developed at some length by Mr. Heaviside, in his paper in the *Electrician* for January 23rd, 1891. To one of them Lord Kelvin had previously called attention ("Collected Papers," Vol. iii., p. 450). Starting with a quasi-labile ether, then we may suppose that μ, the magnetic permeability of the medium, is $4\pi\rho$ (if we adopted Mr. Heaviside's rational system of units the 4π would disappear) where ρ is the density, and that K, the inductive capacity, is $1/4\pi$ B, B being the rigidity, or the quasi-rigidity conferred by the rotation. The kinetic energy of such a medium is $\frac{1}{2}\rho(\dot{\xi}^2 + \dot{\eta}^2 + \dot{\zeta}^2)$, where ξ, η, ζ are the components of the displacement. Let us identify this with the electro-magnetic energy $(\alpha^2 + \beta^2 + \gamma^2)\,8\pi$, α, β, γ being components of the magnetic force, so that $\alpha = \dot{\xi}$, $\beta = \dot{\eta}$, $\gamma = \dot{\zeta}$. Then the components of the displacement, assuming them to be zero initially, are given by—

$$f = \frac{1}{4\pi}\left(\frac{d\dot{\zeta}}{dy} - \frac{d\dot{\eta}}{dz}\right), \text{ &c.;}$$

that is, the electric displacement, $\mathfrak{D}$, multiplied by 4π is equal to the rotation in the medium. Denote this by $\mathfrak{Q}$. The potential energy due to the strain is

$$\tfrac{1}{2}\,\text{B}\,\mathfrak{Q}^2, \text{ or } \tfrac{1}{2}\,16\pi^2\,\text{B}\,\mathfrak{D}^2,$$

and on substituting for B this becomes

$$\frac{1}{2}\,\frac{4\pi}{\text{K}}\,\mathfrak{D}^2,$$

which is Maxwell's expression for the electrostatic energy of the field. Thus so far, but no farther, the analogy is complete: the kinetic energy of the medium measures the magnetic energy, the potential energy measures the electrostatic energy. The stresses in the ether, however, are not those given by Maxwell's theory. In the other form of the analogy we are to take the inductive capacity as $4\pi\rho$, and the magnetic permeability as $1/4\pi$ B. The velocity measures the electric force, and the rotation the magnetic force, so that electrostatic energy is kinetic, and magnetic energy potential. Such an arrangement is not so easy to grasp as the other. Optical experiments, however, show us that in all probability it is ρ, and not B, which varies; while from our electrical experiments we know that K is variable, and μ constant; hence this is a reason for adopting the second form. In either case we look upon the field as the seat of energy distributed per unit of volume according to Maxwell's law. The total energy is obtained by integration throughout the field. Now, we can transform this integral by Green's theorem to a surface integral over the boundary, together with a volume integral through the space; and the form of these integrals shows us that we may look upon the effects, dealing for the present with electrostatics only, as due to the attractions and repulsions of a certain imaginary matter distributed according to a definite law over the boundary and throughout the space. To this imaginary matter, then, in the ordinary theory, we give the name of electricity. Thus an electrified conducting sphere, according to these analogies, is not a body charged with a quantity of something we call electricity, but a surface at which there is a discontinuity in the rotation impressed upon the medium, or in the flow across the surface; for in the conductor a viscous resistance to the motion takes the place of rigidity. No permanent strain can be set up. From this standpoint we consider electrical force as one of the manifestations of some action between ether and matter. There are certain means by which we can strain the ether. The friction of two dissimilar materials, the chemical

action in a cell are two; and when, adopting the first analogy, this straining is of such a nature as to produce a rotational twist in the ether, the bodies round are said to be electrified; the energy of the system is that which would arise from the presence over their surfaces of attracting and repelling matter, attracting or repelling according to the inverse square law. We falsely assign this energy to such attractions, instead of to the strains and stresses in the ether. Such a theory has many difficulties. It is far from being proved; perhaps I have erred in trespassing on your time with this crude form. The words of the French *savant*, quoted by Poincaré, will apply to it: "I can understand all Maxwell except what he means by a charged body." It is not, of course, the only hypothesis which might be formed to explain the facts, perhaps not even the most probable. For many points the vortex sponge theory is its superior. Still I feel confident that in time we shall come to see that the phenomena of the electro-magnetic field may be represented by some such mechanism as has been outlined, and that confidence must be my excuse for having ventured to call your attention to the subject.

RELATIVE COST OF CONDUCTORS WITH DIFFERENT SYSTEMS OF ELECTRIC POWER TRANSMISSION.

By Mr. GISBERT KAPP.

(*Read before Section G, September 18th.*)

IT is just twenty years ago that the reversibility of the dynamo-electric machine was discovered, and with it the transmission of electrical power. The machines then and until recently employed were of the continuous current type, but within the last few years transmission of power by some form of alternating current apparatus has come into use, chiefly because it enables us to carry power to a greater distance with a moderate weight, and, therefore, moderate cost of conductors. The reason for this economy lies in the fact that owing to the scheme of commutators, and the facility and certainty with which alternating current transformers can be insulated, the effective pressure at which the current is transmitted, is much greater with alternating than with continuous currents. To put it in another way, with continuous current plant the voltage is limited by the difficulty of insulating the generating and receiving machinery. With alternating current plant there is no necessity of high insulation of generators or motors, but only of the step up and step down transformers, and since this type of apparatus can, by the use of oil or other means, be insulated to any desired extent, it is the difficulty of insulating the line rather than the machinery which limits the voltage that can be safely employed. In comparing the various systems of transmission as regards economy of material we must put all on the same basis, by so designing the plant that there shall be in each case the same stress on the insulation, or in other words that the difference of potential between any two points in the circuit, or between any point and earth, shall not exceed the predetermined limit. The systems of transmission which have as yet been practically employed, and which alone even claim our attention here, are the following: single-phase alternating current transmitted by two wires; double-phase alternating current transmitted by four wires; double-phase transmitted by three wires; three-phase alternating current transmitted by three wires; continuous current transmitted by two wires. The last case, although practically impossible for extra high pressures, is here included because it gives us a financial standard of comparison for the other four methods of transmission. It is well known that in every circuit the different parts of which are equally well or equally badly insulated the electrical centre of gravity remains always at zero potential, and it follows from these reasons that if the circuit carry an alternating current, the absolute potential of any point undergoes cyclical change, bringing it in turn above and below the potential of the earth by an equal amount. Thus in a circuit carrying 10,000 effective volts, the greatest potential difference between two points will be 14,000 volts, and the greatest possible value of the absolute potential will be 7,000 volts, positive or negative. The insulation to earth will, therefore, be put under a stress not exceeding 7,000 volts; if, however, one point on the line were earthed, the stress at every point would immediately rise to 14,000 volts. We can now compare the continuous and single-phase alternating current as regards weight of copper required for the line, assuming that in both cases the same total power and the same efficiency of transmission. Let us fix the greatest permissible stress at 7,000 volts from the earth, then it will be immediately clear that the effective voltage of transmission in the case of the alternating current is 10,000 volts, and in the case of continuous current 14,000 volts, and since the weights of copper for equally efficiency conditions varies inversely as the square of the pressure, it follows that the transmission of power with alternating current requires twice as much copper as continuous. With two-phase currents and completely duplicated circuits, *i.e.*, four wires in a line the same holds good, as will be obvious on considering that each circuit half carries the power, but how does the case stand if we bunch two of the wires. In this case we have half the current in each of the external wires and about 70 per cent. of the current in the middle wires resulting apparently in a saving of copper, but this is a fallacy; not only is there no saving of copper, but we require actually more copper than with a single-phase system, on the four-wire double-phase system. The reason being that if we tie two of the terminals together we forcibly displace the electrical centre of gravity of each circuit, causing the potential of the other terminals to vary between wide limits. To keep the stress on the insulation down to given limit, we must, therefore, lower the voltage of each circuit, and this means that we must use more copper in the line. Similar investigations made for the three-phase system shows that the effective voltage in each circuit must be lower than with a continuous current, but may be higher than with a single-phase alternating current. I shall not occupy time by giving the mathematical investigations of the various cases previously mentioned, but will simply state the practical result. If we put all the systems on the same footing as regards efficiency of safety of insulation we find the following:—If for the transmission of a certain power over a given distance by continuous current, 100 tons of copper are required for the line, then the single-phase alternating and the two-phase four-wire system will require 200 tons, the two-phase three-wire system will require 290 tons, and the three-phase three-wire system only 150 tons. As far as the line is concerned there is thus a distinct advantage in the employment of the three-phase system.

NOTE ON THE UTILISATION OF WASTE WATER-POWER BY ELECTRICITY.

By Mr. ALBION T. SNELL.

(*Read before Section G, September 18th.*)

ON the Continent water-power is extensively used for driving electric plants, but in Great Britain, for a similar purpose, power is usually derived from the combustion of coal.

This difference in practice is partly the result, no doubt, of the relative supply of water-power in the neighbourhood of places where electric plants would prove commercially profitable; but it is also largely due to the relative cost of fuel. We do not possess abundant natural sources of water-power in or near our large manufacturing districts, and even if we did it is not probable that with coal at the average price of the last 10 years, water-power would prove much cheaper when the capital invested, interest, and cost of maintenance of the electric plant were taken into consideration. But we may with reason pause to ask two questions: Will coal at such a price be always obtainable? And do we make the most of such water-power as we have and can profitably use? Let us look at the second question first. Liverpool is supplied with water from Lake Vyrnwy, in North Wales, the total difference of head being about 500 feet. There must be a considerable quantity of power in the conduit. Is any of it utilised? And if not, does the reason lie in the fact that fuel at present is so cheap? Could the Manchester Water Works, which form a magnificent series of artificial lakes, be utilised to drive turbines and give electric energy for lighting the various towns in their vicinity? Again, the watershed behind Greenock has a fall of many hundred feet, and the water is only partly utilised to drive mills. These are only a few instances in which water-power might, perhaps, be advantageously used for driving turbine dynamos. There are, of course, numerous mountain streams which could be dammed, and thus converted into reservoirs for feeding turbines.

England has been so prosperous in the past by reason of large supplies of coal, hitherto cheap and certain, that the consumers of power have scarcely realised the necessity of any change, and can with difficulty be brought even to contemplate the utilisation of waste water-power. On the Continent, however, coal is found in only a few districts, and fuel is generally dear in comparison with the prices current in Great Britain, and dearer still in relation to local wages and prices. Necessity has thus prepared Swiss, German, and Italian manufacturers, for a radical innovation, which gives them a cheaper power by utilising mountain streams. It is no mere figure of speech to say that natural obstacles in the way of trade competition have led to the development of this important branch of engineering on the Continent, while the very prosperity of Great Britain has tended to hinder progress in this direction. We may ask ourselves in all seriousness whether the present price of coal is likely to be maintained, and whether it would not be wise to make the most of such water-power as we have by using it as an adjunct to, if not as a substitute for, coal. This is quite possible in many places, since power can be transmitted electrically at high pressure for distances of 20 miles or so with a loss not exceeding from 15 to 20 per cent.

There is still much misconception on the part of the responsible advisers of manufacturers and mineral owners as to the possibilities of electricity for the transmission of power, and a lingering distrust, largely due, no doubt, to the financial booms in electric stocks some 10 years ago. But the experience gained during the last decade is gradually making itself felt, and the most conservative must admit it has given us the means of utilising natural water-power in a far more efficient manner than was formerly possible.

The following brief reference to a few of the Continental plants will give an idea of some of the methods of utilising water-power.

Fürstenfeld-Bruck.

This installation is illustrative of how a small town may be supplied by electricity for lighting and power purposes when there is water-power in the neighbourhood. The power station in this case is about 4½ miles distant from the town. There are two alternators of 38 kilowatts each, driven by turbines. The alternators work in parallel at 2,600 volts, and are driven by belting from the main shaft of the turbines. The transmission conductors are two copper wires, ¼-inch in diameter, carried by insulators on posts. At the distributing station there are 10 transformers, whose secondary circuits feed the distributing network at 100 volts pressure. The secondary network is above ground, there being no need to incur the extra expense of laying it in culverts. Single-phase alternate-current motors are running on this circuit. The turbines are designed for a total output of 180 H.P., equivalent to about 4,000 lamps of 8 C.P. at Fürstenfeld-Bruck, and another dynamo will be added as soon as required. At present the load consists of 3,000 lamps of 8 C.P., seven arcs, and motors aggregating about 18 B.H.P. The cost of installation, including secondary cables of sufficient size to serve all the houses in the town, is about 16s. 6d. per 8 C.P. lamp at present installed; and the cost of running is estimated at 10s. per lamp, on a

basis of 2,400 lamps burning at the same time. The charge for private lighting calculated for these figures is about 5½d. per unit.

Tivoli Station for the Electric Lighting of Part of Rome.

This installation is unique in many respects, and is worthy of special consideration. Its full capacity is about 2,000 E.H.P. The waterfalls of Tivoli, about 330 feet in height, and averaging 40 cubic feet per second, form the source of power. The main channel has been arranged to feed three pipes, each of which feeds three turbines of the Girard type, two of 330 H.P., and one of 50 H.P., all being coupled direct to dynamos running at 170 and 375 revolutions per minute, respectively. The whole of this apparatus is underground. The large alternators give 45 ampères at 5,000 volts, and are coupled in parallel. The smaller turbines run the exciters, which are each capable of exciting three alternators. The length of the high-pressure line is about 17 miles, and there are four naked conductors carried on oil insulators. The transformer station is near the Porta Pia just outside the walls of Rome, the pressure there being about 4,000 volts, so that the drop of pressure on full load is about 20 per cent. In the station are two banks of 16 transformers each, which reduce the pressure to 2,000 volts in the secondary mains. Transformers are installed on the premises of the different consumers to reduce the 2,000 volts to the supply service of 100 volts, and there are also transformers capable of feeding 600 arc lamps for street lighting, of which about 250 are already installed.

Lauffen-Heilbronn.

This installation is an example of power transmission by rotary or multiphase currents.

The power station has four turbines of 330 H.P. each, running at 35 revolutions per minute, with 3·85 metres fall. The alternators are coupled through gearing, and each gives 4,000 ampères at 50 volts. This current is passed through the primary circuit of a step-up transformer, and is raised to a pressure of 5,000 volts. At this pressure the power is transmitted through three bare copper wires, insulated by means of oil insulators on high poles. At Heilbronn, step-down transformers reduce the pressure to 1,500 volts, and feed the distributing network on which the house transformers are placed, the final pressure at the consumers terminals being 100 volts. Several large motors and a number of small ones are run off the circuits, the distribution of power in small units being one of the special objects of the installation. These motors are self-starting, and of very simple construction, the small ones having neither commutator nor brushes, and the larger ones not commutators, but only collecting rings and brushes to admit of adjusting the exciting current. The price charged for lighting is, approximately, 9d. per Board of Trade unit, while for motors and heating purposes the price is fixed at 4d., and there is also a sliding scale which gives reductions to large consumers. The total cost of the works is said to be, roughly, £13,000, and there are at present about 4,000 lamps of 8 C.P., 20 arc lamps, and about 20 motors. The full capacity of the plant when finished will be 19,000 lamps of 8 C.P., or their equivalent in power.

The Genoa Power Station.

At 30 kilometres from Genoa, at a height of about 550 metres above the sea level, dams were thrown across two valleys, and thus formed two artificial lakes, having together a capacity of about 4,600,000 cubic metres, and capable of supplying 500 litres of water per second. About 140 metres of the total head were utilised for some years to drive more than 300 small hydraulic motors, and the remaining head of about 364 metres was wasted.

In 1888 arrangements were made to utilise this power electrically, and in order to get the maximum effect from the head, three reservoirs were constructed at different levels. The first reservoir is 130 metres below the main outlet; the second 108 metres lower, and the third 144 metres below the second. A power station is built at each reservoir, the available water power at each being respectively 746, 720 and 960 H.P. These are named after three of the most celebrated Italian electricians, the highest being called the Pacinotti station, the middle one the Volta station, and the lowest the Galvani station. The plan of operations is to drive constant current dynamos at these stations, and to transmit the power to a number of widely separated motors coupled in series, the pressure being varied at the stations according to the load on the circuit. The most distant motor is 30 kilometres away, and the total length of the conductors exceeds 100 kilometres. To the three stations are coupled two circuits of copper wire, 9 mm. in diameter, bare throughout most of its length, but insulated where it passes through villages, and laid in the ground when crossing railways. The maximum pressure employed is about 8,000 volts, and the minimum about 450, which just suffices to drive the current of 47 ampères through the circuits. The dynamos are six-pole Thury machines, and are each designed for about 1,000 volts and 47 ampères. At "Galvani" there are two such dynamos, self-exciting, and coupled directly through flexible couplings to a Girard turbine giving 150 H.P. at a maximum speed of 475 revolutions per minute. The regulation is accomplished by varying the speed of the turbine by a throttle-valve worked by hand; this device, of course, being only applicable to a single unit.

At the "Volta" station the generating plants consists of four groups of machines, each of one 140-H.P. turbine, coupled direct to two dynamos of 1,000 volts, and 47 ampères each. These eight dynamos are connected in series, and are, therefore, able to supply current at a maximum pressure of 8,000 volts. At this station the speed of the turbines is maintained constant, the regulation of pressure being effected by varying the excitation of the dynamos, which are separately excited from a machine driven by an independent turbine, the speed of which is varied by an electric regulator. These turbines were designed by Messrs. Faesch & Piccard, of Geneva, and have very sensitive governors, acting through a small motor which moves the "gate" of the regulating turbine. These keep the speed constant within about 2 per cent., even when half the load is suddenly taken off. The dynamo armatures are made as heavy as possible to assist the governing. This method of regulation, however, is found to cause trouble from insulation difficulties, and therefore at "Paccinotti," which was the last of the three stations to be erected, variable speed with self-excitation was again resorted to. The turbines and dynamos are here practically the same as at "Volta," excepting the arrangement for governing the current, which is accomplished by a most ingenious device. The gate of each turbine is controlled by a 1 H.P. motor, worked by relay currents. The armatures have two oppositely wound circuits, each with a separate commutator, and revolve to the right or the left according as one or other of the circuits is traversed by the relay current. A sensitive ammeter is used to make the contacts, and, since the four turbines are acted upon simultaneously by the four motors, a very quick and effective regulation results. The moving parts are made as light as possible, and thus tend to maintain the current constant, for the speed varies inversely as the torque, and therefore the automatic regulator has very little work to do. The arrangement is so sensitive, that although the pressure frequently varies in a few seconds from 8,000 to 2,000 volts or less, the current is practically constant.

Cassel Plant.

This installation is especially interesting as an example of the utilisation of alternate-current transmission and direct current distribution. The power station is some miles from Cassel, and consists of two turbines and two high-pressure alternators. These are coupled in parallel, and the current is carried by a concentric cable to two sub-stations, in each of which there is an alternate-current motor. Each station has two continuous-current dynamos coupled rigidly, with the alternate-current motor between them. The current is supplied to consumers at 100-volts pressure on the three-wire system, and at one of the stations there is a storage battery.

These plants have been instanced because they are typical of continental practice. They differ widely, both as regards size, method, and details; but they are all designed on the broad lines of utilising waste water-power, and transmitting its energy electrically to towns where it can be usefully expended.

Alternate currents appear to be generally selected, perhaps because they offer more advantages than direct currents for high pressures, and are generally more easily managed. And in several cases it has been deemed advisable to use a direct-current distribution with an alternate current transmission, as at Cassel. The Genoa installation is an exceptional case, as it is simply a power plant, and the main object is to drive a number of widely scattered motors. Yet without a closer acquaintance with the conditions and peculiarities, the writer cannot pass an opinion on the wisdom of the choice of a constant current service. But, at any rate, much credit is due to the engineers for overcoming the difficulties in connection with maintaining the current constant. It must also be borne in mind that this plant was practically designed before the advent of a really reliable asynchronous and self-starting alternate current motor; and it is quite possible that in the light of modern experience a similar scheme would be dealt with by an alternate current system.

The Lauffen-Heilbronn plant is at present the only important instance of a rotary current system, and there considerable difficulty is found in balancing the load on the two circuits. In fact, however useful the multiphase currents may be for power plants pure and simple, in which a constant pressure of supply is not necessarily of primary importance, it appears to be abundantly proved that they are not suitable for lighting, as then constant pressure is absolutely necessary.

A scheme for damming the River Reuse and conveying the water to a storage and distributing reservoir, having a capacity of 3,000,000 cubic feet, at Combi Garrot, is under consideration at present. The water will be distributed to the communes of Neuchâtel, Loche, and La Chaux-de-Fonds, and power will be distributed electrically to distances varying from 7½ to 11 miles. This is a striking instance of the possible utilisation of water-power. There are scores of turbine-dynamo plants in different parts of the Continent, varying from 20 to 500 H.P., chiefly used for driving mills and lighting small towns, and even villages. For example, the plants at Chur, Schio, Lugano, Bellinzona, Reichenhall, Macerata, &c.

In England there are only a few installations which derive their power from water, such as the small central station for lighting Lynmouth and Lynton, and a few private installations. A scheme, on a large scale, for electrically lighting Worcester by means of power derived from the River Severn is in hand, and will, no doubt, lead to similar plants.

The Greenside Silver Lead Mines, Patterdale, Westmoreland.

One of the most important instances of the application of water-power for electric power transmission in Great Britain at present, is that at the Greenside silver lead mines in Cumberland, which was designed by the writer about three years ago in conjunction with the mine manager, Mr. Borlase. These mines are among the few that find it possible to compete with foreign mines, and this is the case partly owing to a fine grade of ore which contains a large percentage of silver, cheaply extracted by crystallisation, but largely because the use of electricity for winding, hauling and pumping has decreased the cost of working.

On the east slopes of Hellvelyn lies a small natural lake, called the Red Tarn, and on the north-east the impounded water of Keppel Cove. Between the two waters rises the hill of Catstycam, at the base of which the two overflows join, and near to which the Greenside Siver Lead Mining and Smelting Company have erected their turbine-dynamo station. The water is lead from an elevation of 1,750 feet above sea level, and flows through an open watercourse 1¼ miles in length to a large reservoir, from which it is conveyed down the hill side for a distance of 360 yards in 15-inch cast-iron pipes.

The fall at the station is equivalent to a vertical head of 400 feet, and the effective horse-power is about 200.

The generating station contains one of Gilkes & Co.'s Vortex turbines of 100 H.P., driving a four-pole compound dynamo made by the General Electric Power and Traction Company. The house is large enough to duplicate this plant when necessary, and pipes, water-courses, &c., are already laid for this purpose.

The electric current is conveyed by two bare copper conductors on poles for six furlongs, to where it enters the mine at an elevation of 1,850 feet above the sea level. The conductors from this point are insulated, and covered with lead. About three-quarters of a mile in the mine, or 1½ miles from the dynamo, a 9-H.P. series motor is employed to wind ore from a set of sinkers. Further into the mine another quarter of a mile, and down 120 yards at the bottom level, is fixed another 9-H.P. motor, working a three-throw pump, forcing the water 360 feet in height.

About midway between these motors there is fixed a dynamotor, which reduces the pressure from 600 to 250 volts for working an electro-locomotive in the lowest day level of the mine, through which runs the water pumped from the 120-yards level, and the whole of the water used by two hydraulic winding engines. Four horses formerly worked this level. The locomotive runs with 12 waggons, the total weight when loaded being 18 tons, and does the work of the four horses with the greatest ease. The conductors in the level are phosphor bronze wire, and the current is fed to the locomotive by four contact pulleys. The difficulties encountered in fixing this plant, and wiring the level, can only be appreciated by the practical man.

All main stations in the mine are lighted by incandescent lamps in series of six. The installation reflects credit on the manager, Mr. Borlase, for his enterprise in recommending the scheme to his directors, and for his perseverance in carrying it out in the face of much opposition from the miners and others interested in maintaining the old state of affairs.

The chief difficulty attending the use of water-power is the irregular and sometimes intermittent character of the supply, and hence it is necessary to exercise great care in judging the suitability of water for given work. This can be obviated to a large extent by building reservoirs and regulating the output according to the power required; but when lighting forms an important part of the scheme, secondary batteries may be used most advantageously. Accumulators act not only as reservoirs, but also as regulators, storing up excess of power, and giving it out when the prime power is insufficient or the turbines are stopped. They are, therefore, especially useful on installations for combined power and light when the water-power varies intermittently. And they may be made a source of economy when power is not required both by day and by night, and owing to the want of a suitable reservoir the water runs to waste during the idle period; then accumulators may be used to store the major part of this energy for electric lighting, metallurgical, or even power purposes.

It will be gathered that the writer is fully aware the small water-power of Great Britain can never show results equivalent to those obtained on the Continent, yet there is undoubtedly much water-power wasted here that is capable of being profitably utilised. His object is simply to call attention to the improved means of utilising water-power by turbine dynamos, and to suggest that prompt measures be taken to conserve as much power as possible by a proper attention to the building of dams and reservoirs wherever this may be feasible. And that such power should be used if convenient, to the exclusion of coal, and, if not so, as an auxiliary power, the steam plant being used as a stand-by as much as possible. This proposal, if properly carried out, would decrease the total consumption of coal to a greater extent than is generally supposed, and would make a number of manufacturers less dependent upon it than they are to-day, even if it did not appreciably cheapen the cost of power. But in a number of favoured cases there can be no doubt that water-power properly applied would considerably decrease the cost of working, allowing a proportionate gain to both producer and consumer.

ON THE PIEZO-ELECTRIC PROPERTY OF QUARTZ.

By Lord KELVIN.

(*Read before Section A, September 15th*, 1893.)

SECTION 1. In the present communication we are not concerned with the six-sided pyramid, or planes parallel to the sides of a six-sided pyramid, seen at the ends of a quartz crystal farthest from the matrix. Nor are we concerned with the transverse striæ generally seen on the sides of the prism, which are undoubtedly steps (probably having faces parallel to the faces of the terminal pyramid) by which the prism becomes less in transverse section from the matrix outwards. We shall consider only a perfect, and therefore an unstriated, hexagonal prism. The sides of the prism may be, and generally are, unequal in nature, but the angles are all exactly 120°. For simplicity of reference to the natural crystalline form, I shall suppose the prism to be equilateral, which it may be in nature, as well as equiangular, which it must be. Thus we have three planes of symmetry, which for brevity I shall call the diagonal planes, being planes through the opposite edges of the prism. We have also three other planes of symmetry, which for brevity I shall call the normal planes, being planes perpendicular to the pairs of parallel faces.

Section 2. In the brothers J. and P. Curie's beautiful instrument for showing their discovery of the piezo-electric property of quartz, a thin plate of the crystal about half a millimetre thick, I believe, is taken from a position with its sides parallel to any of the three normal planes of symmetry; its length perpendicular to the faces of the prisms, and its breadth parallel to the edges. The sides of this plate are, through nearly all their length, silvered by the chemical process to render them conductive,* and are metallically connected with two pairs of quadrants of my quadrant electrometer. I find that the effect is also well shown by my portable electrometer; the two sides of the quartz plate being connected respectively to the outer case, and the insulated electrode of the electrometer. In an instrument which has been made for me under Mr. Curie's direction, the silvered part of the plate is 7 centimetres long and 1·8 broad. A weight of 1 kilogramme hung upon the plate placed with its length vertical causes one side to become positively electrified, and the other negatively.

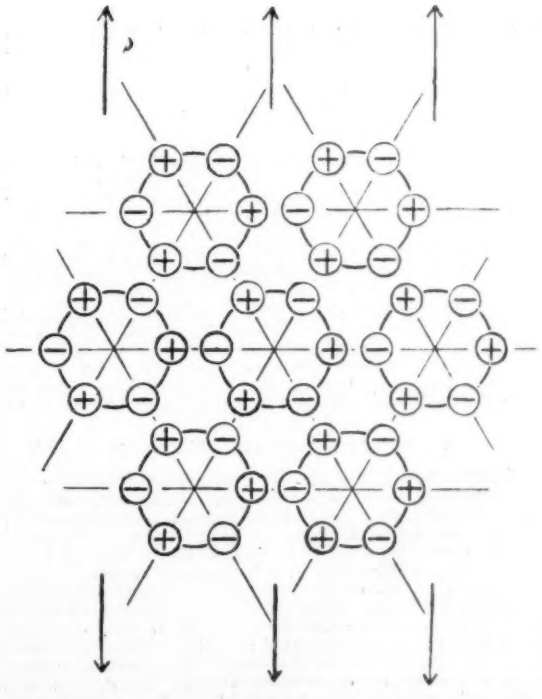
Section 3. A plate parallel to any one of the three normal planes of symmetry will give the same result of transverse electro-polarisation; but a plate cut parallel to any one of the three diagonal planes of symmetry will give no result in the mode of experimenting described in section 2. But with its sides unsilvered it would, if properly tested, show positive electrification at one end and negative at the other when stretched longitudinally, as we see by the hypothesis and theoretical considerations which I now proceed to explain; and by section 11 below without any hypothesis.

Section 4. Electric eolotropy of the molecule, and nothing but electric eolotropy of the molecule, can produce the observed phenomena. The simplest kind of electric eolotropy which I can imagine is as follows:—For brevity I shall explain it in relation to the chemical constitution which, according to present doctrine, is one atom of silicon to two atoms of oxygen. The chemical molecule may be merely SiO_2 for silica in solution or it may consist of several compound molecules of this type, grouped together; but it seems certain that, in crystallised silica (in order that the crystal may have the hexagonally eolotropic piezo-electric property which we know it has) the crystalline molecule must consist of three SiO_2 molecules clustered together; or must be *some* configuration three atoms of silica and three double atoms of oxygen combined. As a ready and simple way of attaining the desired result, take a cluster of three atoms of silicon and three double atoms of oxygen placed at equal distances of 60° in alternate order, silicon and oxygen, on the circumference of a circle.

The diagram, fig. 1, shows a crystalline molecule of this kind surrounded by six nearest neighbours in a plane perpendicular to the axis of a quartz crystal. Each silicon atom is represented by + (plus) and each oxygen double atom by − (minus). The constituents of each cluster must be supposed to be held together in stable equilibrium in virtue of their chemical affinities. The different clusters, or crystalline molecules, must be supposed to be relatively mobile before taking positions in the formation of a crystal. But we must suppose, or we may suppose, the mutual forces of attraction (or chemical affinity), between the silicon of one crystalline molecule and the oxygen of a neighbouring crystalline molecule, to be influential in determining the orientation of each crystalline molecule, and in causing disturbance in the relative positions of the atoms of each molecule, when the crystal is strained by force applied from without.

Section 5. Imagine now each double atom of oxygen to be a small negatively electrified particle, and each atom of silicon to be a particle electrified with an equal quantity of positive electricity. Suppose

Fig. 1.



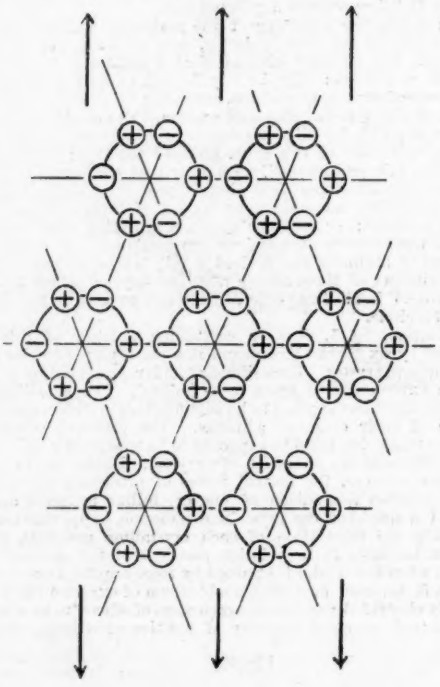
now such pressures, positive and negative, to be applied to the surface of a portion of crystal as shall produce a simple elongation in the

* For a description and drawing of this part of their instrument, given by the brothers Curie, see Appendix to the present paper.

direction perpendicular to one of the three sets of rows. This strain is indicated by the arrow-heads in fig. 1, and is realised to an exaggerated extent in fig. 2.

This second diagram shows all the atoms and the centres of all the crystalline molecules in the positions to which they are brought by the strain. Both diagrams are drawn on the supposition that the stiffness of the relative configuration of atoms of each molecule is slight enough to allow the mutual attractions between the positive atoms and the negative atoms of neighbouring molecules to keep them in lines through the centres of the molecules, as fig. 1 shows for the undisturbed condition of the system, and fig. 2 for the system subjected to the supposed elongation. Hence, two of the three diameters through atoms of each crystalline molecule are altered in direction, by the elongation, while the diameter through the third pair of atoms remains unchanged, as is clearly shown in fig. 2 compared with fig. 1.

Fig. 2.



Section 6. Remark, first, that the rows of atoms, in lines through the centres of the crystalline molecules, perpendicular to the direction of the strain, are shifted to parallel positions with distances between the atoms in them unchanged. Hence, the atoms in these rows contribute nothing to the electrical effect. But, in parallels to these rows, on each side of the centre of each molecule, we find two pairs of atoms whose distances are diminished.

Section 7. This produces an electric effect which, for great distances from the molecule, is calculated by the same formula as the magnetic effect of an infinitesimal bar-magnet whose magnetic moment is numerically equal to the product of the quantity of electricity of a single atom into the sum of the diminutions of the two distances between the atoms of the two pairs under consideration. Hence, denoting by N the number of crystalline molecules per unit bulk of the crystal; by b the radius of the circle of each crystalline molecule; by q the quantity of electricity on each of the six atoms or double-atoms, whether positive or negative; by ϑ the change of direction of each of the two diameters through atoms which experience change of direction; and by μ the electric moment* developed per unit volume of the crystal, by the strain which we have been considering and which is shown in fig. 2; we have

$$\mu = N q \,.\, 4\, b\, \vartheta \cos 30^\circ = N \,.\, 2\, b\, q\, \vartheta\, \sqrt{3} \qquad (1).$$

It is, of course, understood that ϑ is a small fraction of a radian.

Section 8. To test the sufficiency of our theory, let us first consider quantities of electricity which probably, we may almost say certainly, are present in the atoms in nature.

Instead of the silicon atoms marked + in the diagram let us substitute globes of polished zinc; and, instead of the double oxygen atoms marked −, let us substitute little globes of copper well oxidised (polished copper, heated in air till it becomes of a dark-slate colour). Let us suppose all the six atoms of each compound molecule to be metallically connected, and all the molecules insulated from one another. We are not concerned with conceivable permeation of electricity by conductance through the crystal; and, therefore, we must suppose the total quantities of electricity on each crystalline molecule to be zero. Let the circle of each compound molecule in the diagram be a real exceedingly thin stiff ring of metal, no matter what kind of metal, and let each of the six atoms be a bead (a perforated spherule), whether of zinc or of copper, moving frictionlessly on it. Thus we have, in idea, a working model of an electrically eolotropic crystalline molecule.

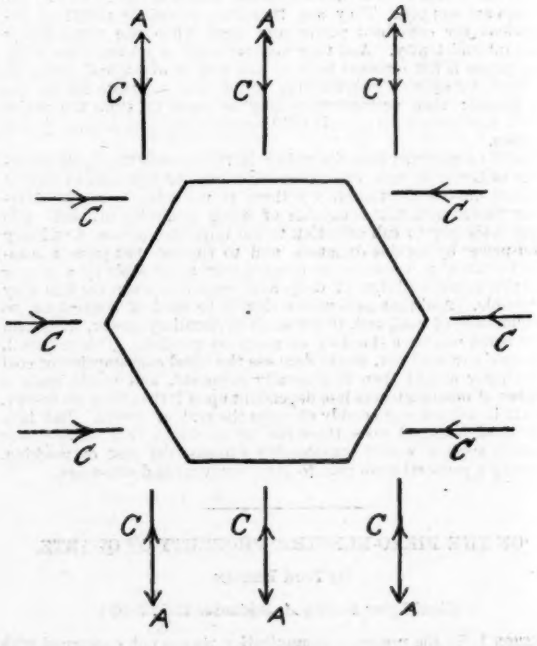
Section 9. I have found by experiment* that the difference of potentials in air, besides a polished surface of zinc and an oxidised surface of copper, is about ·004 of a C.G.S. electrostatic unit, provided the zinc and copper are metallically connected. Hence, if a be the radius of each spherule, we have approximately $q = ·002 \times a$; because we shall suppose for simplicity that, except the infinitely thin ring on which it is movable, no spherule has any metal within a distance from it of less than two or three times its diameter. Let now $N = 10^{21}$ per cubic centimetre; and let b be a quarter of $N^{-\frac{1}{3}}$, that is to say, $b = \frac{1}{4} \times 10^{-7}$ of a centimetre. Lastly, to give definiteness to our example, let $a = ·2 \times b$. Equation (1) becomes

$$\mu = 866\, \vartheta \qquad (2).$$

Section 10. From the admirable statement of Messrs. Crrie of the result of their measurements quoted in the Appendix of the present paper, I find that a stretching force of 1 kilogramme per square centimetre, in their experiment described in Section 2, produces an electric moment of ·063 C.G.S. electrostatic reckoning per cubic centimetre of the crystal. Thus about $\frac{1}{4}$rd of a C.G.S. unit of electric moment per cubic centimetre is produced by 5 kilogrammes per square centimetre of stretching force; and this, according to equation (2), requires ϑ to be 1/2598, which is an amount of change of direction among atoms quite such as might be expected in pieces of crystal stretched by forces well within the limits of their strength. A rough mechanical illustration of the theory of electric atoms to account for the piezo-electric properties of crystals, is presented in an electrically working model of a piezo-electric pile, submitted to Section A in a separate communication at the present meeting of the British Association.

Section 11. I shall conclude by proving, without any hypothetical assumption, the statement at the end of Section 3. Consider first a simple elongation perpendicular to one of the three pairs of parallel sides of the hexagon in fig. 3, as indicated by the arrow-heads,

Fig. 3.



A, A, A, A, A, A, in fig. 3. Superimpose now two equal negative elongations, one of them in the direction of the original elongation, and the other in a direction perpendicular to it. These negative elongations, indicated by the twelve arrow-heads marked C, constitute a condensation equal in all directions; which produces no change on the electrical effect of the first simple elongation. But it leaves us with a simple negative elongation in the direction perpendicular to that of the original positive elongation; which therefore alone produces the same effect as that which was produced by the original one alone. Thus we see that if elongations perpendicular to the three pairs of parallel sides produce electro-polarisations with electric axes in each case perpendicular to the line of elongation, equal elongations in the directions of the diagonals produce electric polarisations equal to those, but having their axes along the lines of elongation instead of perpendicular to them.

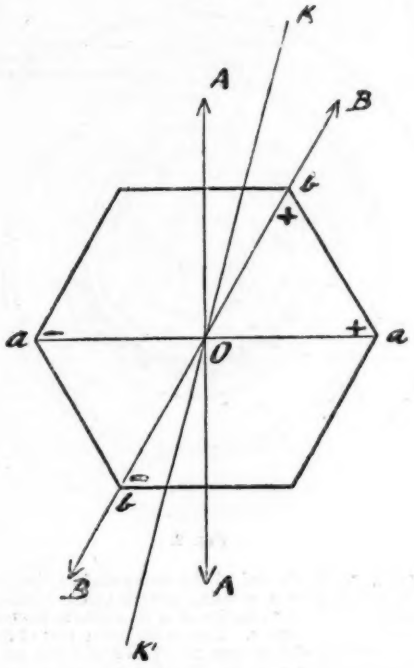
Section 12. Consider now two simple elongations in the direction shown by the arrow-heads, A, in fig. 4. These two elongations produce electro-polarisations with axes and signs indicated by a, a, and b, b, respectively. The resultant of our present

* I do not know if this designation has hitherto been used. I introduce it with precisely the same significance relatively to electricity, as the well-known "magnetic moment" in reference to magnetism.

* "Electrostatics and Magnetism," section 400, and experiments not hitherto published, by another method.

two simple elongations is clearly a dilatation equal in all directions in the plane of the diagram, compounded with a single simple elongation in the line K', O, K, bisecting the angle between them, and of magnitude equal to $\sqrt{3}$ times the magnitude of each of them, as is easily proved by the elementary geometry of strain. Hence an elongation in the direction K', O, K, does not produce zero of electric effect. In fact, there are no "Axen fehlender Piëzo-electricität." The three axes, so called by Röntgen,* are the lines of elongation in

Fig. 4.



Curie's experiment. Without sufficient consideration it might be imagined that the six lines corresponding to K', O, K, in fig. 4, are "Axen fehlender Piëzo-electricität." On the contrary, elongation in the line K', O, K, produces an electro-polarisation which is the resultant of the equal polarisations indicated by a, a, and b, b, and which, as it bisects the angle b, O, a, is in a line inclined at 45° to O', K, the line of the elongation. In fact simple elongation in any direction perpendicular to the principal axis of a quartz crystal produces electro-polarisation; and it is only when the lines of two simple elongations are coincident with one another, or are perpendicular to one another, that the resultant of their electro-polarisations can be zero.

Section 13. A most important contribution to our knowledge of the electric properties of crystals has been made by Röntgen,† and by Friedel and J. Curie,‡ in independent investigations proving that the irregular electrifications of the corners of quartz crystals, which had been observed by many observers as consequences of heatings and of returns to lower temperatures, are wholly due to mechanical stresses developed by inequalities of temperature in different parts of the crystal. Those phenomena are therefore truly *piezo-electric*, and are not at all "pyro-electric" like the electric property of tourmaline which is due to change from one temperature to another, each the same throughout the crystal. The very important and interesting discovery thus made by Röntgen and by Friedel and Curie, is, as they have pointed out, available also to explain the perplexing and seemingly paradoxical statements regarding positive and negative electrifications of corners and hemihedral facets at opposite ends of the four long diagonals of crystals of the cubic class, and of cubes of boracite, which had been given by previous observers and writers, and which have not yet disappeared from elementary treatises on mineralogy, electricity, and general physics.

APPENDIX.

[Extract from a pamphlet published by the *Société Centrale de Produits Chimiques*, 42, 43, Rue des Ecoles, Paris.]

Quartz Piézo-Electrique de MM. J. *et* P. CURIE.

Cet instrument se compose essentiellement d'une lame de quartz, sur laquelle on exerce des tractions à l'aide de poids placés dans un plateau. Cette action mécanique provoque un dégagement d'électricité sur les faces de la lame.

La lame de quartz, a, b, c (fig. 5), est montée solidement à ses extrémités dans deux garnitures métalliques, H et B. Elle est suspendue, en H, à la partie supérieure; elle soutient, à son tour, en B, à la partie inférieure, le plateau et les poids, par l'intermédiaire d'une tige munie de crochets.

L'axe optique du quartz est dirigé horizontalement, suivant la largeur, a, b, de la lame. Les faces sont normales à un des axes binaires (ou axes électriques) du cristal. On exerce les tractions dans le sens vertical, c'est-à-dire dans une direction à la fois normale à l'axe optique et à l'axe électrique.

Les deux faces de la lame sont argentées.

Fig. 5.

On a tracé dans l'argenture de chaque face deux traits fins, m, n, m', n', qui isolent des montures la plus grande partie de la surface. On recueille l'électricité, sur ces portions isolées, à l'aide de deux lames de cuivre faisant ressort (r, r, r, r), qui viennent s'appuyer sur les deux faces et communiquent avec les bornes de l'appareil.

Lorsque l'on place des poids dans le plateau, on provoque le dégagement de quantités d'électricité égales et de signes contraires sur les deux faces de la lame.

Lorsque l'on retire des poids, le dégagement se fait encore, mais avec inversion des signes de électricité dégagée sur chaque face.

La quantité d'électricité dégagée sur une face est rigoureusement proportionnelle à la variation de traction, F.—On a

$$q = 0{\cdot}063\,\frac{L}{e}F.$$

L est la longueur, m, m' de la partie argentée utilisée. e est l'épaisseur de la lame.

F est exprimé en kilogrammes et q est donné en unités C.G.S. électrostatiques.

On a donc avantage, lorsque l'on veut avoir des effets très sensibles, à prendre une lame longue dans le sens de la traction et peu épaisse dans le sens de l'axe électrique. La dimension parallèle de l'axe optique n'a pas d'influence sur la quantité d'électricité dégagée.*

La lame de quartz est placée dans une enceinte métallique desséchée. Cette cage métallique, toutes les pièces métalliques de l'instrument et les montures de la lame de quartz sont mises en communication permanente avec la terre.

Le modèle No. 2 comporte encore un commutateur et un levier qui sert à soulever les plateaux et les poids. Nous reviendrons plus loin sur le rôle de ces organes.

ON A PIEZO-ELECTRIC PILE.

By Lord KELVIN.

(*Communicated to Section A, September 15th*, 1893.)

The application of pressure to a voltaic pile, dry or wet, has been suggested as an illustration of the piezo-electric properties of crystals, but no very satisfactory results have hitherto been obtained, whether by experiment or by theoretical considerations, so far as I know. Whatever effects of pressure have been observed have depended upon complex actions on the moist, or semi-moist substances between the metals and electrolytic or semi-electrolytic and semi-metallic conductances of the substances. Clearing away everything but air from between the opposed metallic surfaces of different quality, I have made the piezo-electric pile which accompanies this communication. It consists of twenty-four double plates, each 8 centimetres square, of zinc and copper soldered together, zinc on one side and copper on the other. Half a square centimetre is cut from each corner of each zinc plate, so that the copper square is left uncovered by the zinc at each of its four corners. Thus each plate presents on one side an

* Wiedemann's *Annalen*, 1883, xviii., p. 215.

† *Ber. der Oberrh. Ges. f. Natur- und Heilkunde*, xxii. (of date, between December, 1882, and April 30th, 1883).

‡ *Bulletin de la Société Minéralogique de France*, t. v. p. 282, Decembre, 1882.

And *Comptes Rendus* of French Academy of Sciences, April 30th, and May 14th, 1883.

* Double breadth, which doubled stretching force, would give double quantity.

uninterrupted copper surface, and on the other side a zinc surface, except the four uncovered half square centimetres of copper. A pile of these plates is made, resting one over the other on four small pieces of India-rubber at the four copper corners. The air-space between the opposed zinc and copper surfaces may be of any thickness from half a millimetre to 3 or 4 millimetres. Care must be taken that there are no minute shreds of fibre or dust bridging the air-space. In this respect so small an air-space as half a millimetre gives trouble, but with 3 or 4 millimetres no trouble is found.

The lowest and uppermost plates are connected by fine wires to the two pairs of quadrants of my quadrant electrometer, and it is generally convenient to allow the lowest to lie uninsulated on an ordinary table and to connect it metallically with the outer case of the electrometer.

To make an experiment (1) connect the two fine wires metallically, and let the electrometer needle settle to its metallic zero.

(2). Break the connection between the two fine wires, and let a weight of a few decigrammes or kilogrammes fall from a height of a few millimetres above the upper plate and rest on this plate. A startlingly great deflection of the electrometer needle is produced. The insulation of the India-rubber supports and of the quadrants in the electrometer ought to be so good as to allow the needle to come to rest, and the steady deflection to be observed, before there is any considerable loss. If, for example, the plates are placed with their zinc faces up, the application of the weight causes positive electricity to come from the lower face of the uppermost plate, and to deposit itself over the upper surface of plate and weight and on the electrode and pair of quadrants connected with it.

ON A NEW FORM OF VARIABLE POWER GEAR FOR ELECTRIC RAILWAYS AND TRAMWAYS.

By W. WORBY BEAUMONT, M.Inst.C.E.

(*Read before Section G, September 18th.*)

IT is a matter of great importance on electrical railways and tramways that the maximum steam engine power at work in the generating station should be as little above the mean load as possible.

It is found on electrical railways now at work that there is a great waste of power, and therefore of fuel, in consequence of the large consumption of current in getting the trains into motion by motors attached directly to the axles. On the South London Railway it is found that the power employed electrically in overcoming the inertia of the train is from 25 to 50 and 60 per cent. greater than that required to keep the train going.

Mr J. H. Greathead, M.I.C.E., the engineer of this railway, has shown that if this could be avoided, from 20 to 30 per cent. of the engine power, which must under present conditions be kept running, might be shut down. The author showed this by diagrams representing the variation in the consumption of power in the working of this railway, as given by Mr. Greathead.*

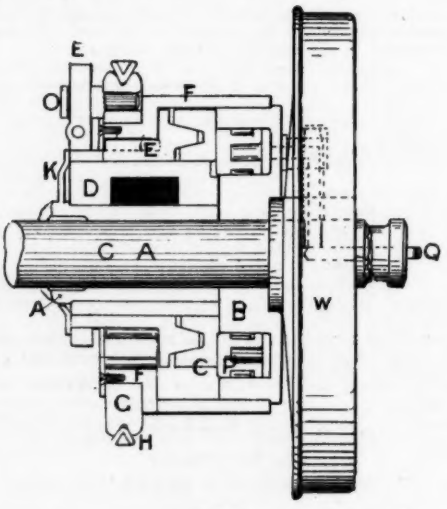


FIG. 1.

For several reasons the employment of geared locomotives is undesirable on railways, although single reduction gearing is most generally adopted for tramways, and probably will remain best for that purpose. The noise made by high speed gearing, and the wear, are both objectionable, otherwise a geared locomotive offers the means of overcoming to some extent the losses referred to.

In the paper the author showed how an intermediate course can be adopted which will remove the loss of power at the generating station. The electric motor is placed directly on the driving axle, but is reduced in size and power to more nearly that of the mean horse-power required on the road. This, for the greater part of the journey of a train from station to station, drives the axle upon which it is placed, at its own speed, just as those do which are now upon the South London Railway. The motor is, however, on a hollow spindle, which drives the axle when starting a train, through the medium of a compact double clutch containing one pair of epicycloidal reducing wheels. The clutches are operated by electro-magnets in one case and by fluid pressure in another.

Power Gearing for Electric Locomotives.—In fig. 1 the gearing is shown as operated by fluid pressure, and arranged as for a locomotive for direct driving. On the axle, C, A, is fixed a disc, B, containing an annular cylinder, or rather chamber, in which is an annular piston, P, which, by admission of oil under pressure, or air from the continuous-brake cylinders, is caused to press, when necessary, against

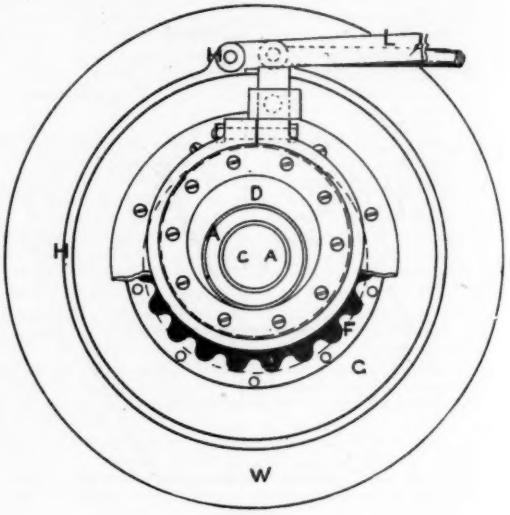


FIG. 2.

gripping ring, G. On the end of the motor shaft, A, is fixed an excentric, D, which gives a gyrating motion to the toothed ring, E. This correspondingly gives motion at a slow rate to the gear ring, F, which is fixed to the disc, B. Upon a projecting part of the internal gear ring is a bridle with an arm, E^1. This arm is free to slide in a bridle, O, pivoted in a ring, G. The ring, G, is either permitted to run free, or is held fast by parts which constitute a brake clutch, of which only the ring, H, and levers, L, are seen.

When it is desired to start a train, the ring, G, is held fast by this apparatus, and O becomes a fulcrum, about which E, with the ring, E,

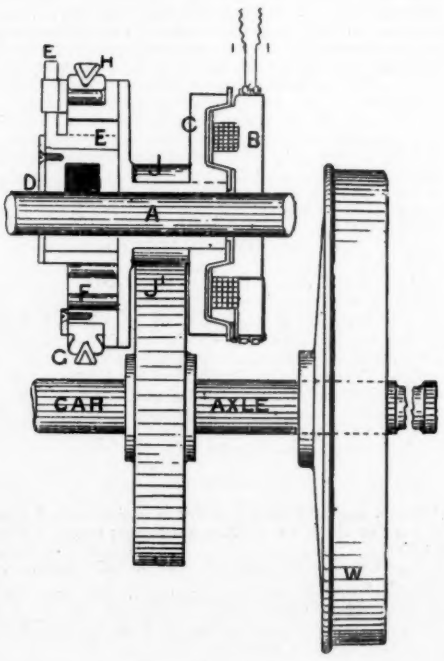


FIG. 3.

gyrates. The locomotive axle is then driven by the wheel or ring, F, at one-fifth the speed of the motor, or a power ratio of 5 to 1. This is required for a few seconds at each start. The inertia of rest of the train having been overcome, the ring, G, is set free, and fluid under pressure admitted at Q, thus pressing the ring, C, upon E. This fixes the whole of the working parts of the gear, and couples the motor-

* *Proceedings*, Institution of Civil Engineers, Vol. cxii.

shaft and locomotive axle, so that the latter is direct driven. The motor can thus run idle, driving nothing, or it may drive the axle at one-fifth of its speed, or at its own speed. When running at normal speed, the whole of the gear described runs as one solid piece, and only works for starting a train or getting up hill. A breakdown would leave the locomotive in the condition of a gearless engine.

The arrangement of the gearing for tramcars, when single-reduction gear is employed, is shown in figs. 3 and 4. In this the motor-shaft, A, carries a disc electro-magnet, B, which has, as an armature, a disc, C, on the boss of the pinion, J, which gears into the wheel, J^1,

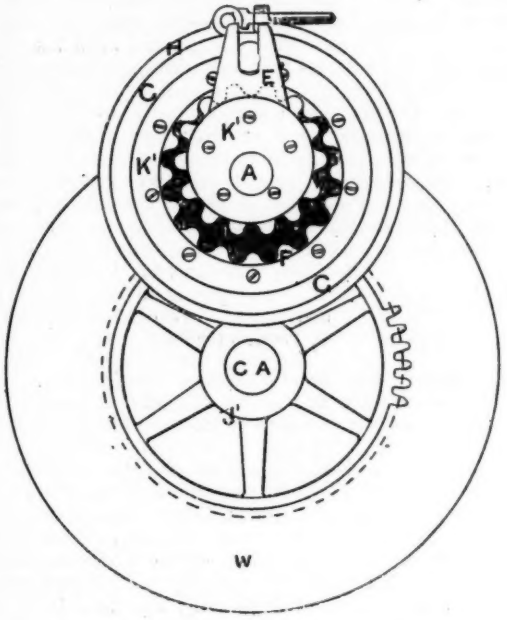


FIG. 4.

on the car axle, the ratio being 4 to 1. The epicycloidal gearing is very similar to that in figs. 1 and 2, and gives, as shown, a speed ratio of 5 to 1. With this arrangement a motor of 15 H.P. would be ample for any tramcar, instead of the 30 H.P. now used. The motor, in starting, may run idle, or may drive the car axle through the epicycloidal gear and single-reduction gear at, say, a ratio of 20 to 1, or by passing a current into the coils and by energising the magnet, B, the whole apparatus runs solid on the motor-shaft, the gear ratio then being that of the single-reduction gear of 4 to 1.

DISCUSSION.

Mr. PITT said that Mr. Beaumont's arrangement certainly got over the difficulty in his previous arrangement, in which the wheels were driven when idle at very high speeds. His firm had found that when wheels doing no work were driven at very high speeds they gave considerable trouble. The gearing looked very well on the diagram, but he feared some of the wheels might be a little out of balance. He would like to see the whole thing worked out in practice.

Mr. KAPP congratulated the author on his gearing arrangement. He (the speaker) had followed with the greatest interest the development of this gear. Mr. Beaumont had found real assistance from fault-finding of his friends. He was glad that the author had abandoned the electric clutch; it was a very pretty arrangement, but he doubted if it was a very reliable one. He had experience of an electric omnibus, the brake of which was worked by an electric clutch; the omnibus was not a success, but the clutch gave the most trouble. It was almost impossible to keep the contacts clean, and if they considered that the whole driving power depended upon such a delicate arrangement, they must prefer air, oil or other means.

Mr. BEAUMONT did not think that the question of balancing the wheels would give much trouble. He would point out that where electric traction displaced animal power, it was usual to displace two horses by a motor of 30 H.P.; this was necessary to get over the difficulty of starting. His arrangement would obviate the necessity of such a large motor, in most cases a motor of half the power of the present motors would be sufficient. He did not think, despite Mr. Kapp's remarks, that he had entirely abandoned the electric clutch; of course, he would prefer a mechanical arrangement where possible.

PARLIAMENTARY NOTES.

IN the House of Commons on Tuesday last, upon the report of the Vote for the Post Office telegraphic service coming up for discussion,

Mr. HENNIKER HEATON, after relating what had been done in reference to the Government taking over the telephones, expressed his opinion that a grosser blunder was never made than that of purchasing the trunk lines of communication whilst leaving in the hands of the company all the local communications. The Government took over the worst paying portion, and left the best paying portion in the hands of the company. The porterage charge for telegrams in the country was a constant source of annoyance to people who lived in the country, and the charges made were very high. Another source of annoyance was the absurd charges made for compound words, which were charged for sometimes as two and other times as three words. He should like to see all these confusing arrangements swept away. It was impossible to understand the principle upon which the charges were made. "Fishmarket" was charged as one word, whilst "cattlemarket" was two; "upstairs" as one word, and "downstairs" two. A telegraphic receipt was charged at 2d., whilst a receipt for £1,000 would only cost 1d.

Mr. THEOBALD complained of irregularities in connection with the appointment of and promotion of clerks in the office.

Mr. BROOKFIELD complained that the present Postmaster-General had taken the step of exactly reversing the policy of his predecessor with regard to the employment of discharged soldiers in the postal service.

Mr. RADCLIFFE COOKE desired to know whether the patronage exercised by Members of that House in their constituencies with regard to the position of sub-postmaster was an absolute one.

Sir A. ROLLIT said he understood that no monopoly had been conceded to the telephone companies, and that licenses might be issued to other people. The great hindrance to the development of the telephone in London was the assertion of private rights in opposition to the general convenience of the community.

Mr. A. C. MORTON said the Bill affecting the telephone companies was rushed through the House in a great hurry, and was not properly considered. He trusted the Postmaster-General would do nothing to assist this monopoly, which would make the evils of the present telephone system press more tightly upon the people than it did at present.

Mr. HOWELL urged the extension of the system of employment of retired soldiers in the Post Office and other branches of the civil service.

Mr. A. MORLEY said he did not propose to enter into the question of the telephone, pending the report of the recommendations of the Joint Committee of the two Houses of Parliament. He could, however, say at once that he should not be prepared to grant to any company the power to open the highways without the consent of the local authorities. He had been connected with a telephone company, and had used a telephone since the instrument had first been introduced, and he was strongly of opinion that two competing companies in one district would destroy half the value of the telephone. The practice of sending telegraph boys, after a certain term of service in the telegraph department, into the Army, was strongly objected to by parents all over the country, and though he did not propose at present to abolish the admission of pensioned soldiers into the Post Office employment, circumstances had come before him which made him think that the system would require some abridgment. The telephone department had caused a loss to the Post Office during the past year of between £30,000 and £40,000, and certainly he could not recommend further costly developments of that kind. With regard to the extension of the postal telegraph service in the country, the right hon. gentleman quoted figures to show that everything was being done that was possible to meet the increased demand.

The resolution was then agreed to.

CORRESPONDENCE.

A New Incandescent Arc Lamp.

Sir David Salomons's letter interested me very much, as I had recently made some experiments with a Jablochkoff candle enclosed in a narrow glass bulb. I cannot, however, agree with him in claiming that a Jablochkoff candle in a closed tube or globe is quite the same thing as described in Mr. Marks's paper. It makes a vast difference if you substitute an arc between the ends of two ordinary sized carbon rods, for the arc between the parallel rods of small diameter in a Jablochkoff candle.

In my experiments with the candle I have obtained some very curious results, not yet interpreted; these shall be published some time in the near future. In Mr. Marks's paper, the carbons are said to be very pure, the glass envelope as small as it possibly can be used, so that it attains a high temperature, this high temperature prevents deposition of carbon on the inside. The arc is regulated by an ordinary arc regulator, and is therefore quite different from a candle.

There can be no increase of pressure in the gases in the bulb, seeing that the carbon must work easily through the cap on the bulb, and the working of the carbon through the cap is not a difficulty, as is supposed by Sir David Salomons.

Rankin Kennedy.

Ocean Telephony.

In Prof. S. P. Thompson's paper at Chicago on the above subject, he proposes a form of cable transformer for ocean telephony and telegraphy, consisting of two insulated copper wires overlapped with iron wire, and he further states that this cable transformer was suggested by Messrs. Siemens and Halske some years ago.

This cable transformer was invented by me, and a length manufactured for me by the London Electric Wire Company, in 1886, that is seven years ago; it is described and claimed in British Patent, No. 12,531, October 2nd, 1886, and in U.S. American Patent, No. 447,569, issued March 4th, 1891.

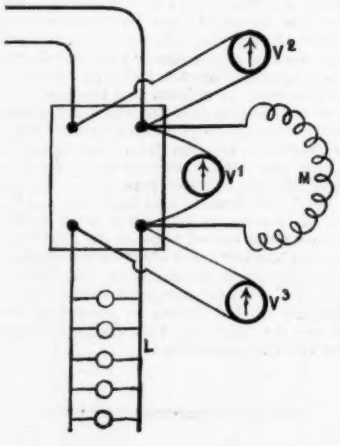
I have a complete record of the electrical properties of this cable transformer obtained by experiment on the length made for me at that date; recently my attention was again turned to this cable, with a view to use it in ocean telegraphy without knowing of Prof. Thompson's similar views, and as the use of transformers generally in telephony and telegraphy has been the subject of a long series of investigations by me, I have been much interested in the Professor's paper, and must say that electrical engineers owe him considerable obligations for his remarkably able contribution to the subject.

Rankin Kennedy.

An Explanation Wanted.

I should be glad if you would give me an explanation of the following experiment:—

M represents 14 10-ampère Westinghouse meters in series with the lamp circuit, L. V represents a Cardew voltmeter



keeping the pressure constant; the three readings were taken on the voltmeter.

$v_1 = 33$ volts.
$v_2 = 99{\cdot}5$ volts.
$v_3 = 80{\cdot}5$ volts.

A current of about 9 ampères was passing. Has the apparent discrepancy anything to do with the capacity of the voltmeter? An explanation would greatly oblige.

T. C. Parsons.

[The discrepancy is due to the self and mutual induction in the Westinghouse meters, the voltmeter has, practically, no capacity. With a continuous current $v^1 + v^3 = v^2$; with the alternating current $v^1 + v^3 = v^2 +$ a quantity which depends on the electro-magnetic inductances in the coils of the Westinghouse meters, a quantity which varies with the frequency and the current.—EDS. ELEC. REV.]

Peterborough Electric Lighting.—Peterborough tradespeople and inhabitants generally are clamouring for the electric light, and a petition to the Corporation is being extensively signed by them. One tradesman has resolved not to wait for the Corporation supply, and is having a private installation put down.

NOTES.

Obituary.—An Appeal for Help.—It is with deep regret that we are called upon to record the death, which happened on Sunday, the 10th inst., of Mr. J. A. Berly. He quite recently had relinquished the agency here of Messrs. Richard Frères, and had returned to the neighbourhood of Paris, where he intended to take up fresh work; before, however, he had time to arrange for a residence or to commence afresh, he was taken suddenly ill, and expired at an hotel at Asnières, at the early age of 47 years. The regret at his loss will be considerably heightened when his many friends and acquaintances here learn that his widow and only daughter are left in the greatest straits, and on their behalf we ask any who can afford a little assistance to kindly send us subscriptions, and we will promptly forward them. In a letter we have received from the young daughter she bravely says: "My mother and myself hope to get on in the future; it is only for the present that we need a little aid." So badly off are they, that they are actually unable to pay their hotel expenses, and had it not been for the kindness of the proprietress of the hotel, they would, we are told, have been perplexed to find the means of paying for the funeral expenses. P.O. Orders and cheques may be made payable to Mr. H. Alabaster, at 22, Paternoster Row, E.C.

The Madras Electric Tramways.—On March 27th last the Madras Electric Tramways Company applied to the Municipality for the extension of its concession for a period of six months, counting from the 6th of the following month (April), when the original concession would have expired, and the final order of Government granting the application was passed on August 15th—that is, four months and nine days after the commencement of the new concession, and one month and twenty-one days before its expiration, the date of which is October 6th next, by which time ground must be broken. *Indian Engineering* says that had "the company sat still until the receipt of this order, obviously it would have had either to apply for a further extension, or to go into liquidation. But, while the authorities were considering, the company was a-doing, with the result that things are in such a forward state, that by October 6th, the 'Benighted City' will have seen the beginning of the *actual* construction of the first electric tramway in Asia (*sic*). Although, in the honest discharge of our duty, we have dealt the promoters of this tramway scheme some hard blows, yet we shall be amongst the first to congratulate them when that event is an accomplished fact."

The Fatal Electric Lighting Accident.—On Friday last week, Mr. A. C. Langham, Deputy Coroner for Southwark, at Guy's Hospital, opened an enquiry with reference to the accidental death of Frederick William Ball, aged 35, at the Blackfriars Sub-Station of the L.E.S.C., to which we referred in our last issue. Major Philip Cardew represented the Board of Trade. Philip Hunt said that he knew the deceased. On Tuesday night, about half-past six o'clock, he was called into the station of the London Electric Supply Corporation, Limited, Blackfriars Road, where he found the deceased lying on the floor between two converters and a stool. He appeared to be dead. He also met a young man named Meech at the door, and he was much burned. Meech said that whilst he was dusting down, someone had turned the main on, but witness found that that was not the case, as, on looking up, he found that the switch-gear was down. John George Freeman, the engineer in charge of the London Electric Supply Corporation Station at Blackfriars, stated that he was of opinion that the deceased had received a shock whilst engaged in dusting, having left a connecting plug in, whereas it ought to have been out at the time. The deceased had been in the corporation's employment for a number of years. He was always a very careful man. Dr. Hamilton said he saw the deceased between seven and eight on Tuesday evening. There was a ragged wound on the back of his right wrist and hand, and the flesh was charred. There was also a similar wound on the back of the left wrist, and the injuries had the appearance of having been caused by electricity. Other evidence showed that Meech had been very badly burned, and would not be able to leave the hospital for some time, and the enquiry was eventually adjourned for a month for his attendance.

Death of an Electrical Engineer.—An electrical engineer named Mr. Alfred H. Whiffen, travelling from Adelaide to Plymouth, died from an overdose of morphia taken by misadventure. The heat while coming through the Red Sea was most oppressive, and Mr. Whiffen suffered considerably from insomnia, and having drunk some morphia in the smoking room retired to his cabin, where he was subsequently found in an unconscious condition. Efforts to restore animation were unsuccessful. The deceased was buried at sea.

The Rating of Machinery.—The valuers to the Chesterfield Union (Messrs. Hedley & Co.) lately re-valued the factory of Messrs. Hewitt, Bunting & Co., increasing the rating from £84 to £460! Seeking the aid of the Machinery Users' Association, the firm were advised to appeal. The result so far is that the Assessment Committee, at the hearing on Thursday, when the appellants were represented by Mr. Humphreys-Davies, reduced the new valuation of £460 to £168, but as even this amount is believed to be excessive, a further appeal is to be made to the Sessions. These appear to be some of the results of attempting to rate machinery.

A Strike.—It is not a great while since we announced a strike in one department at the factories of the Edison and Swan United Electric Light Company at Ponder's End, because of some disagreement among the *employés* in the fitter's department. For a very different cause is it, says the *Financial Times*, that the instrument makers employed by the company have now resolved to come out on strike. These men were some time ago informed that there would be a reduction in their rate of pay, and the men offered to accept a reduction equal to 12½ per cent. This offer was not accepted by the management, it being considered insufficient, and the matter having now been reconsidered by the men, they have determined to take the step referred to above.

Perils of the High Tension System.—A correspondent of the *Star* considers that "the circumstances attending the death of F. W. Ball, who was killed at the Blackfriars Station of the London Electric Supply Corporation, should not be allowed to pass unnoticed. Admitting that Ball was an experienced workman, and knew the danger he would incur, I doubt very much if the deceased was aware that the plug was turned on. No experienced man would wilfully run such a great risk knowing the terrible danger of the high tension system. I hope that the matter will be carefully inquired into by experts, and the machinery at the Blackfriars Station thoroughly overhauled by an inspector of the Board of Trade, as accidents of this kind are not sufficiently inquired into. I cannot help thinking that there must be great negligence on someone's part for such accidents to occur."

The "Excelsior" Battery.—"R. A." writes to the *English Mechanic and World of Science* as follows:—"I was extremely interested in the description given by F. Williams in your last issue of the 'Excelsior' battery. The advantages claimed for it are, indeed, 'incongruous to conceive,' and 'wonderful to entertain.' We are not, however, informed how the current of air is to be forced through the sealed cell by means of 'a piece of flexible *catouche* tubing,' in order to re-oxidise the depolariser. Would not this necessitate an air-pump? Moreover, as this would necessarily be a somewhat prolonged operation, I fail to see the especial advantage of it, especially if there are several cells to be so treated. The loss in time would, I should think, more than counterbalance the gain in economy of chemicals. This all seems to me to be nearly as complicated a modification of the chromic-acid double fluid cell as was the 'Osbo-Premier' battery, which was advertised in your paper some two years ago, and of which I am forcibly reminded by F. Williams's description of the 'Excelsior' battery. This battery (the Osbo-Premier) was such a 'success,' that the supply did not nearly equal the demand, with the result that, as F. Williams may remember, Messrs. Clarke & Montague, the Osbo-Premier Battery Company, the Springdale Electric Company, and several other firms, had to retire from public life for a considerable period. Let us hope that a similar misfortune may not overtake F. Williams's invention, as there is sure to be a great demand for such a novelty."

The Post Office and the Telephone.—It is now understood that the agreement between the Postmaster-General and the telephone companies will not be laid on the table of the House of Commons until the autumn sitting.

Arc Lamp.—"Old lamps for new" seems to be the cry of arc lamp inventors. *L'Electricien*, July 22nd, illustrates and describes an arc lamp in which the two carbons, situated at the bottom of the lamp, are inclined to each other, resembling the letter V, with the arc at the apex. This invention is also described in the "Digest" of the New York *Electrical World*. The idea is certainly not a new one. If our memory does not deceive us, we saw such a lamp at the Crystal Palace Electrical Exhibition about 12 years ago, and we believe that Mr. Killingworth Hedges was responsible for it.

Telegraphic Communication with Zambesia.—In our last issue we published a short note on this subject. We now learn that on Friday last the Portuguese Government formally confirmed the contract of March 28th last with the Portuguese Companhia Zambesia, conferring upon it exclusive rights for the construction and working of a network of telegraphs between the Zambesi Tete, Quilimane Chinde, and other localites. Besides the cable connecting Quilimane and Mozambique, pursuant to Article 11 of the Anglo-Portuguese Treaty, the Government is empowered to compel the company to make telegraphic connections across Portuguese territory between the opposite frontiers, reaching the latter from British territory.

Radiation of Bodies within the Electric Furnace.—M. Violle has recently made experiments in which he finds that carbon, chalk, magnesia, zircon, and oxide of chromium, though totally different substances, have in the electric furnace the same brilliancy, and give the same impression to the eye or to the photographic plate. In placing a small piece of carbon in the path of the arc, he finds that it is rapidly consumed, and becomes hollow on the side towards the cathode; while on the other side towards the anode it is covered with pulverised deposit; it appears therefore to act exactly like a metal wire in an electrolytic bath, according to the law of Grotthus. An abstract of the Academy paper is given in *L'Electricien*, and more briefly in the "Digest" of the New York *Electrical World*.

Brighton Electric Lighting.—On Saturday last the marine frontage at Brighton was for the first time lighted by electricity. The weather during the day had been anything but pleasant, owing to the fall of heavy showers; by seven o'clock, however, which was the time for lighting the sea front, the weather had greatly improved, and there were assembled a large number of people to witness the ceremony of inauguration. We have from time to time recorded the continual progress made in the general electric lighting at Brighton. Not long ago the Town Council were compelled to put down additional plant, and laid about nine miles of low-tension mains; they have now 20,000 incandescent lamps nightly lighted. For the lighting of the frontage along the southern promenade, from the Aquarium as far as the western boundary of the burgh, 40 arc lamps are supplied from the existing low-tension mains. The *Daily Telegraph* last Monday, in an article on the subject, says:—"The lighting of the front is unique, in that it is the first installation of the arc lanterns on the ordinary low tension system." This, however, is by no means correct, as the Gülcher Company many years ago lighted arc lamps from low tension circuits. The arc lamps used at Brighton are of 1,000 candle-power, and are placed about 130 feet apart on alternate sides of the sea promenade. At 11 o'clock those on the side nearer the seashore will be extinguished, but the other 20 will not be switched off until dawn. Although something like ten times the amount of light which was given by the gas is provided by the electric light, the difference in the cost is only about £300 a year. The lamp posts, which have been specially designed by Messrs. Walter Macfarlane & Co., of Glasgow, are 28 feet high. Messrs. Crompton & Co. have supplied the lamps and canopies, but all the rest of the work has been carried out by the Corporation, under the direction of Mr. Arthur Wright, their electrical engineer. The "switching on" ceremony was performed by the Mayoress of Brighton.

Burnley Electric Lighting. — The electric lighting works have now been formally handed over to the Corporation. It is not at present proposed to light the thoroughfares by means of electricity, except at, perhaps, the chief centres, but already many of the tradesmen have had installations made upon their premises, and most of the public buildings have been lighted from the electric mains. By way of advertising the completion of the works, an enormous searchlight of 32,000 C.P. was placed upon the Town Hall the other evening.

Electrical Quackery in America.—In the course of some remarks at the recent Chicago Congress, Prof. Silvanus Thompson took the opportunity of smiting a blow at electrical quackery in America. He remarked that England had in this respect gone ahead of America by condemning electrical nostrums which were vended with the purpose of fraudulently taking money from the public pocket. Prof. Thompson referred in the course of his remarks to the recent exposure by the ELECTRICAL REVIEW, of London, and, according to New York *Electricity*, he scored the American electrical journals for their failure to perform their obvious duty in enlightening the public as to the true status of these humbugs.

Prof. Ayrton's Chicago Paper.—A New York contemporary, commenting on the paper read by Prof. W. E. Ayrton on "Variations of the Potential Difference of the Electric Arc with Current, Size of Carbons, and Distance Apart," states that this was evidently the result of a great deal of experimenting on the part of the author. It was profusely illustrated with curves and diagrams, and while it was simply the result of a series of experiments, results were obtained which will prove of value to the carbon manufacturers, inasmuch as new facts and data have been obtained which should be of material benefit towards economy in their manufacture. A box of carbons which Prof. Ayrton took with him, and which he exhibited, were examined with a great deal of attention by those interested. They were the ends of the rods which he had used in the experiments and tests described in his paper.

Profits of Electric Railroads.—Our American namesake, speaking of the increased profits arising from the substitution of electricity for horses, states that "a prominent railway man said: 'We are not in this business for fun; our business is to make money, and you may be sure that if the companies lost money by the introduction of electricity we would not see as many lines as now exist in this country.' Facts speak for themselves. Among the many reports of increased earnings coming in from different parts of the country we select a few. In Columbus, O., where electricity superseded horses, there was an increase in the earnings of 20 per cent. In Lincoln, Neb., 70 per cent. In Superior, Wis., there was a remarkable increase of 96 per cent. in gross earnings, and of 150 per cent. in net. This increase is far in advance of the increase in population, and in large cities the average increase in net earnings is about 90 per cent., simply because of the greater amount of travel, and not on account of an increase in the price of fares."

Dr. Cornelius Herz.—Some months ago there was much commotion regarding Dr. Cornelius Herz, who was said to be lying seriously ill at Bournemouth. Everyone supposed he was still there as nothing had been stated to the contrary, but we are now suddenly informed, through the columns of the Paris *Figaro*, that he is now no longer at Bournemouth, but occupies his time in travelling. He is reported to have gone to France *viâ* Belgium, and to have had interviews with several persons, who gave him the assurance that he was quite safe now. At present he is engaged in disposing of his real estate, with the intention of finally residing in America.

Since the above paragraph was published in the *Figaro*, the following semi-official note has been made public in Paris:—"Contrary to the statements published by some newspapers during the last few days, it is quite incorrect that the French Government has modified the formal instructions given from the outset to our Representative in London in view of obtaining the extradition of Dr. Cornelius Herz. In regard to Dr. Herz's present state of health, the Foreign Office, at the request of our Chargé d'Affaires, is about to direct a fresh medical examination to be made."

Wakefield and Electric Lighting. — A provisional order is to be applied for by the City Council.

Dundee Electric Lighting Extensions.—It has been resolved to erect 36 new electric lamps in various streets in the centre of the city, and to remove the gas lamps there at present in use.

Chesterfield Electric Lighting.—The inhabitants have been circularised as to the probable consumption of electric light current. Out of 261 circulars only 13 replies have been received.

Halifax Proposed Electric Tramways.—Last week the Town Council considered a proposal to erect an electric tramway on the overhead wire system at Halifax. The council resolved that it was inopportune at present to take steps in the matter.

Ocean Telephony.—In an article on the Chicago Electrical Congress, the New York *Electrical Review* says that Mr. Charles Cuttriss, electrician to the Commercial Cable Company, who was one of those who discussed Prof. S. P. Thompson's paper on "Ocean Telephony," stated that it was a well-known fact that a small amount of leakage was found to reduce the capacity of the cable, but that, like "the darkest part of the day is just before the dawn," it only occurred shortly before the cable required repairing. In the exhibit of the Commercial Cable Company at the World's Fair, there are represented numerous examples of broken, tangled and leaking cables. One particularly noticeable example is a small length of the gutta-percha covered conductor in which is a small hole not larger than that made by a pin. This, of course, permitted the entrance of the salt water, thus rendering the cable useless for the time being. The cable was picked up within a quarter of a mile of this defect and a new piece inserted. "What was the cause of this defect?" I asked Mr. Cuttriss. "There are several theories concerning its cause," he replied. "Messrs. Siemens Bros. have one theory and I have another. I believe that a single fibre of hemp or jute became imbedded in the gutta-percha when the cable was being made, and in due course of time, by capillary action, the water soaked into the fibre and rotted it. As soon as this took place it was but the matter of a very short time before the leak was complete and the cable was disabled. This is merely a theory, but if anyone has a solution, I believe that if it is a practical one he will be handsomely rewarded by Siemens Bros."

Mr. J. B. Henck, jun., writing to the New York *Electrical Engineer* on the subject of distributing remedies in ocean telephony, says:—"I have only just had time to read, in the *Engineer* of August 30th, the paper of Prof. S. P. Thompson on the above subject. It is one in which I have taken some interest, and on which I began to work about a dozen years ago. Reference to the patent records will show that in 1881 I proposed and patented a form of cable similar in general plan to that now proposed by Prof. Thompson, and I believe entirely free from any objection on the score of difficulty of manufacture or of laying. Circumstances have prevented my following the subject since that time, but I have never given up the belief that I was then on the right track, and that important results would have followed had I been able to induce anyone to risk the necessary capital in experiments on a practical scale. This I could not do, and the matter has lain dormant ever since. I do not claim that I anticipated all that Prof. Thompson now proposes. Inductive shunts were not heard of at that date. But the general idea of a 'distributed remedy' is clearly shown in my patent, and I did not need to shift any of the responsibility of successful manufacture upon the 'cable engineer,' as the form I proposed could be made and laid without any difficulty with existing machinery. My American patent was assigned to the American Bell Telephone Company, and the English patent is No. 4,058, of 1881, and is dated September 20th of that year. I think it due to myself to make this mention of my work, in view of Prof. Thompson's statement that a 'distributed remedy' had never before been proposed. It was proposed, but was so far in advance of the times that, like Goebel's lamp, it was quite lost sight of again before the time was ripe for it, if, indeed, it is so yet. The doubts with which Prof. Thompson's proposal is received seem to indicate some uncertainty on this point even now."

Yarmouth Electric Lighting.—The Town Council have set apart, for the purpose of an electric light station, a piece of land on the east side of the Southgates Road, measuring 140 feet from north to south, and 100 feet from east to west.

Newport Electric Lighting.—The Electric Lighting Committee have recommended that Mr. Robert Hammond be appointed as consulting electrical engineer at a commission of £5 per cent. upon the cost of the installation (exclusive of land) to cover all travelling and out-of-pocket expenses, and the service of a resident engineer to act as clerk of the works.

The Waterhouse Arc Lamp.—We were this week invited to see the Waterhouse lamp in operation any day between 12 and 1. An hour, even if one could ensure the whole time being occupied with the object in view, is none too long to investigate, even superficially, the special points of merit claimed for this regulator, so we must content ourselves for the present by saying that it behaved as any well-regulated lamp should.

Penywern Technical College.—The prospectus for the forthcoming session has just been published. Classes are to be held dealing with a variety of subjects, among them being mathematics, physics, electrical, civil and mechanical engineering, which will be conducted principally by Mr. Geo. W. de Tunzelmann. For chemistry and other subjects there is an efficient staff of teachers. Intending students should secure a copy of the prospectus, which is obtainable from the principal, at the college, Penywern House, 204, Penywern Road, Earl's Court, S.W.

Electric Railways in Europe.—*L'Ind. Elec.* has recently given some statistics with reference to European electric railways, which were reproduced in the ELECTRICAL REVIEW. The data are not quite complete, but, as far as possible, they have been summarised by the New York *Electrical World*, and the following table is given in the "Digest" of the latter journal :—

Country.	Number of roads.	Miles of road.	Thomson-Houston and Sprague.	Siemens & Halske.	Miscellaneous.	Overhead trolley.	Accumulator.	Conduit and central rail.	Underground.
Germany ...	16	98·1	79·5	18·6	...	91·5	...	...	5·6
England ...	16	49·5	5·6	11·4	32·5	15·8	8·1	21·2	3·2
France ...	12	54·7	35·0	0	19·7	43·3	11·4	...	...
Austria ...	3	39·3	0	36·2	3·1	2·66	...	33·5	...
Switzerland	8	17·1	5·4	0	11·7	17·0	...	...	...
Italy ...	4	12·3	10·4	0	1·9	10·4	...	...	...
Russia ...	2	9·0	4·7	...	4·3	4·7	...	...	...
Spain ...	1	8·7	8·7	...	...	8·7	...	...	...
Sweden ...	1	4·7	4·7	...	...	4·7	...	...	...
Belgium ...	2	3·4	3·4	...	...	3·4	...	...	...
Holland ...	1	...	...	...	...	...	...	...	...
Totals ...	66	296·8	157·4	66·2	73·2	202·1	19·5	54·7	8·8

The table includes the roads in construction as well as those about to be constructed. It will be seen that by far the larger proportion are of American origin. The newer roads are almost exclusively of the Thomson-Houston system. The mileage of the roads among the four different systems have been divided to show how very much the overhead trolley method predominates, the principal exceptions being the conduit road in Budapest, the accumulator roads in France and England, and the central railroad in England. It will be observed that over two-thirds of the total mileage the overhead trolley system is used.

NEW COMPANY REGISTERED.

Shillingford Works Company, Limited (39,574).—This company was registered on the 14th inst., with a capital of £10,000, in £1 shares, to acquire the business now carried on by John Pomroy Hitchcock and H. Field, at Shillingford, under the name of the Shillingford Works Company; to enter into an agreement with this end in view, and to carry on the business of electricians, mechanical engineers, &c. The subscribers (with 1 share each) are: J. P. Hitchcock, Shillingford, Oxon, engineer; H. Field, Hillcott, Brockhurst Hill, engineer; A. J. Estcourt, Shillingford, Oxon, engineer; A. Estcourt, Gloucester, builder; T. Forty, Shillingford, corn merchant; J. Monty, High Street, Wallingford, grocer; W. J. Reynolds, Shillingford Bridge, hotel proprietor. Registered without articles of association by Preston, Stow and Preston, 35, Lincoln's Inn Fields, W.C.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Birmingham Electric Supply Company, Limited.—The last annual return of this company shows that out of a nominal capital of £100,000, in £5 shares, the whole of these shares have been taken up. A sum of £5 has been called on each of 10,000 shares, and £2 on each of the remaining 10,000. The total amount of calls paid reaches £70,000.

Tayler Smith Electric Company, Limited.—The annual return of this concern has lately been filed, and shows that out of a nominal capital of £6,000, in £10 shares, 299 preference and 300 ordinary shares have been taken up. A sum of £10 has been called on each of the preference shares, and £3,000 has been agreed to be considered as paid on the 300 ordinary shares. There is still £10 unpaid.

South of England House-to-House Electricity Company, Limited.—The last return of this company shows that out of a capital of £100,000, in £5 shares, 107 shares have been taken up. Nothing, however, has been remitted, but a sum of £500 has been agreed to be considered as paid.

Newcastle-upon-Tyne Electric Supply Company, Limited.—The annual return of this company shows that out of a capital of £50,000 in £5 shares, 6,104 shares have been taken up with £4 called on each. The total amount of calls received, including payments on application, &c., and those paid in advance, equals £25,984. A sum of £215 has been agreed to be considered as paid on 43 shares.

Scottish House-to-House Electricity Company, Limited.—It appears, from the last annual return of this company, that the original capital of the concern was £100,000 in £5 shares, and that only seven shares had been taken up. There has been nothing paid on these.

Northern House-to-House Electricity Company, Limited.—According to the latest return, filed at Somerset House, it seems that only 107 shares have been taken up out of a capital of £100,000 in £5 shares, and that £500 has been agreed to be considered as paid.

Shropshire Electric Light and Power Company, Limited.—The first annual return of this company has been lately made, and shows that out of a nominal capital of £25,100 in 2,500 ordinary shares of £10 each, and 100 founders' shares of £1 each, 275 ordinary and 44 founders' shares have been taken up, and a call of 5s. per share made on the first class, while no calls have been made on the founders' shares. There has been £595 5s. paid on this account, and £22 10s. is still outstanding. There is no alteration in the figures of the third annual return, which was filed at the same time as the above.

Northampton Electric Light and Power Company, Limited.—The last annual return of this company shows that out of a nominal capital of £50,000, in £1 shares, 10 "A," 10,000 "B" ordinary, and 3,180 "B" preference shares have been taken up. On each of the 10,000 shares £1 has been called, 10s. on the 3,180, and on the remaining 10 "A" shares nothing at all has been called. The total amount of calls received reaches £12,875.

CONTRACTS OPEN AND CLOSED.

OPEN.

Blackburn.—October 27th. The Corporation invite tenders for the supply and erection of machinery and plant for electric lighting the borough. Full particulars will be found among our advertisements.

Liverpool.—No date stated. Tenders are invited for lighting the Caledonia Foundry and Engine Works, Brazenose Road, Liverpool. The premises can be inspected, and all information obtained on application to the proprietors, James Buchanan & Son.

CLOSED.

Cambridge Guildhall.—For the installation of electric lighting in certain portions of the Guildhall (the small assembly room, the alderman's parlour, and the exit to Peas Hill) there were two tenders sent in by local firms. That of Messrs. Russell & Co. (late Medhurst) at £37 5s., subject to a slight alteration in lamps to be used in the small room and alderman's parlour, which would entail an additional cost of about £5, was accepted. The other tender, it appears, amounted to more than double that of Messrs. Russell.

BUSINESS NOTICES, &c.

The Universal Electrical Directory (J. A. Berly's), now under the direct supervision of the proprietors, H. Alabaster, Gatehouse & Co., is in active preparation for the 1894 edition (13th year). It will be considerably enlarged, while the price will remain as before, namely, 4s. It is indispensable to all having business transactions in the electrical world, and once used cannot be done without. Advertise in it! Order it! It will prove the best four shillingsworth ever purchased.

Christiania Electric Lighting Works.—The Controllers of the Electric Lighting Works, appointed by the Municipal Authorities of Christiania, have tested the plant according to the conditions prescribed in the tender, and the results of the trials are embodied in the following reports from the technical members of the commission, and in accordance with these reports the controllers recommend that the boiler plant be sanctioned and accepted by the Corporation as being carried out in every way according to the contract. Boiler Trials, March 3rd and 4th.—"The two large boilers being identical, only one was tested for the relative generation of steam compared with the consumption of coke. The test was of four hours' duration. At the beginning of the trial the steam was at full pressure, and this exact pressure, together with the condition of the fire and the exact water level, were duly noted; and care was taken that those conditions also existed at the end of the trial. The steam generated was either used by the engines or allowed to pass through the safety valves. The total water consumed was 12,154 litres, as measured in the feed tank, and during the same period 1,198·5 kilos. of coke were consumed. The coke was found to contain 4 per cent. of moisture and 6 per cent. of ashes, this being tested and accurately measured by Mr. Schmelck, analyst; the net consumption of pure dry coke, therefore, amounted to 1,072·66 kilos. The water evaporated per hour thus becomes 3,038·5 kilos.; water evaporated per square metre of heating surface per hour, 12·154 kilos.; water evaporated per kilo. of dry coke per hour (ashes and moisture deducted), 11·34 kilos. The trial of the small boiler was carried out in the same manner, and the total quantity of water consumed in four hours amounted to 8,425 litres, on a total consumption of coke of 950 kilos. In this case the percentage of moisture in the coke was found to be 1·2 per cent., and the ashes 6·2 per cent., giving a net weight of dry coke, free from ash, of 880 kilos. In this case the water evaporated per hour becomes 2,105·25 kilos. Water evaporated per square metre of heating surface per hour, 13·53 kilos.; water evaporated per kilo. of dry coke per hour (ashes and moisture deducted), 9·58 kilos. As the trials abovementioned showed a lower evaporation per square metre of heating surface than was guaranteed, whilst, on the other hand, the economy of the boiler was considerably higher than prescribed, one of the large boilers was tested subsequently on April 6th for 3 hours, the firing being forced so as to increase the evaporation per square metre of heating surface per hour. This then gave the following results: Total amount of water consumed, 11,400 litres, on a consumption of coke of 1,280·7 kilos.; the quantity of moisture in the coke was found to be 1·2 per cent., and the quantity of ash 7·36 per cent., giving a net weight, free from ashes and moisture, of 1,171 kilos. of coke. From this will be found: Water evaporated per hour equalled 3,864 kilos.; water evaporated per square metre of heating surface per hour, 15·54 kilos.; water evaporated per kilo. of coke per hour (ashes and moisture deducted), 9·73 kilos. The boilers are therefore considered to have satisfied the requirements stipulated in the contract. The economiser proved to be very effective, and the steam pumps, fittings, and pipes were in every respect as contracted for."

Torquay Electric Lighting.—The ratepayers last week met to discuss several matters of local interest. They had considered in a very uproarious manner the question of the salaries of borough officials, and the neglect of the councillors to carry out certain improvements to the quay, when the chairman introduced the next question on the agenda, which was "The electric light scheme." The mention of this had a rather facetious reception, the ratepayers expressing their feelings by shouting out, "Us don't want that!" "Next, please!" It seems from this that there will be a little opposition when the council take up the electric lighting of the town in earnest.

Electric Light Letters for Advertising.—These electric letters are formed of bright plated metal backing of hollow section, mounted on a board to any possible design as required. Into these backings glass tubes of uniform diameter and various lengths, enclosing a filament, are fitted; they are joined direct to the lighting main as if they were on ordinary glow lamps, and form a most powerful means of arresting and sustaining the attention of the public. They can be arranged to switch themselves on at dusk and off at daylight, and are, especially, suited for theatres, railway stations, exhibitions, restaurants, hotels, shops, advertisements in tunnels, underground railways, and every other place where an ordinary advertisement would be useless. The Electrical Advertising Syndicate, Limited, are the proprietors of the invention, and are already erecting these signs in London. The sign "Partington," shown in Charing Cross Underground Railway Station, is an example of the most recent type of letter. The letters in question, have been designed by Mr. Réné Upward, who is consulting engineer to the syndicate. The letters and signs are manufactured complete in every respect, and mounted ready for erection by the Edison & Swan United Electric Light Company, Limited, at their Ponder's End Works.

Telegraphic Communication with Brazil.—The managing director of the Western and Brazilian Telegraph Company, Limited, writes to us as follows:—"With reference to a telegram purporting to have emanated from Buenos Ayres and addressed to the president of the Central and South American Telegraph Company, stating that the office of this company at Rio Janeiro had been abandoned by the staff, permit me to inform you that this company has two offices at Rio Janeiro, the one in the City which has been closed, being in the line of fire, and as its use was not permitted, it was useless to subject the men to unnecessary risk; the other office, a short distance from the town, is out of the scene of operations, and has not been interfered with, thus, when hostilities cease and we are permitted to re-commence business, telegrams will be subject to no delay of any sort whatever. In the meantime, 'through traffic' with the River Plate is not interfered with by our route."

It is since stated that the Brazilian Government have withdrawn their restriction as to the sending of telegrams, but messages must be in plain language and in no way refer to the state of affairs in Brazil.

Sewage Purification by Electricity.—A new system of disinfecting town sewage is now being tested by Messrs. Merryweather & Sons, of London, specially with a view to dealing with the drainage of seaside towns. The idea is that of electrically treating sea water and thereby effecting such chemical changes as to render it a powerful disinfecting solution. A portable "Squires" engine is being used, with a dynamo bolted to its carriage for supplying the electric current, and the new disinfectant is pumped into the sewers by the same engine, the firm's hydraulic sewer flushing apparatus being employed so as to obtain the greatest effect. A somewhat similar system is in use in a town some 20 miles above New York; through this town passes a stream from which the water supply of the City is taken, and has been found to afford a most economical means of effectually destroying organic germs caused by sewage pollution. Should the experiments prove all that is anticipated, a great saving in the purchase of disinfectants will be made, and, the apparatus being comparatively inexpensive, should go a long way towards solving the problem of how to render sewage innocuous at small cost.

Pontypool Electric Lighting.—There have been a number of premises lighted by electricity at Pontypool lately. The improvement in the lighting of the drapers' shops is very marked, and Messrs. E. Fowler, R. W. Woolley, and E. Jones, have all in use a large number of 200 candle-power lamps. The shops of Messrs. W. Pegler & Son and Mr. J. Daniel are also effectively lighted, while Mr. Hall, of the "Ship," lights a considerable part of Crane Street by a powerful lamp placed over the entrance to his hotel. Walker's Coffee Tavern is fitted with the electric light, while on the lower side of the Cross Mr. J. Williams's boot shop is well lighted, as are the drapers' shops of Mr. W. H. Haskins and Mr. C. Jones, in Commercial Street. In George Street Messrs. Edwards and Company, Mr. E. B. Ford, Mr. W. Charles, Mr. Fowler (the Arcade), Mr. Tanner ("Crown" Hotel), Mr. J. Herbert and Captain Gus Beaven are using the new illuminant with satisfactory results, and it seems in a fair way of coming into general use, both for shops and private houses. Among the latter is noticeable Dr. Essex's house.

Lincoln and Electric Lighting.—The Town Council, after considering a notice from the London and Brush Provincial Electric Lighting Company, Limited, of their intention to apply to the Board of Trade for a provisional order to authorise the supply of electricity by the said Company for public and private purposes within the City of Lincoln and certain adjacent parishes, it was resolved:—"That the Council be recommended to refuse the above request, inasmuch as the Corporation themselves possess special facilities for lighting the City with electricity, and are quite prepared to undertake the work as soon as they are satisfied that the true interests and advantages of the inhabitants demand the supply of such a mode of lighting in the City and adjacent parishes."

Catalogues.—The Edison & Swan United Electric Light Company show signs of determination to keep their name and business to the front, if catalogues and circulars will do this. The latest list is one of Ediswan portable batteries, giving prices and directions for use. Everything is neatly set out and the illustrations are very well executed. Accompanying this catalogue we have received a copy of a reprint of a supplement to the *Ironmonger*.

Messrs. Wright's Patent Heater Condenser Company have sent us a list of their specialities. The list deals with water heaters, purifiers, softeners, filters, surface condensers, refrigerators, and compound cylinder release engine.

Taunton Electric Lighting.—The Town Council have received the following report from the Electric Lighting Committee:—"Your committee have ordered that the electrical engineer be instructed to report to every meeting of the committee, and that he be provided with a book for such purpose. The committee have instructed the surveyor to erect a new office at the Electric Lighting Works, using old materials as much as possible. The committee recommend that the following assistants be appointed: Messrs. Couzens, Phillips, and Thornhill, at the respective salaries of £70, £60, and £40, subject to one month's notice on either side, and Witham, without salary, for six months. The committee recommend that the pupils be articled to the Council, and that the engineer be paid quarterly his proportion of the premises. The committee recommend that Mr. Alfred Ernest Witham be retained at his present salary of £30 a year to collect meter rents and other income connected with the electric lighting, and to keep the books connected with the business department thereof in such a manner as will enable the town clerk to carry out the requirements of the Board of Trade. The committee have arranged for Dr. Fleming to visit Taunton during the present month. The committee recommend that underground wires be laid along Billet Street to Salisbury House." The report has, after discussion, been referred back to the committee for further consideration on a certain point. Alderman Standfast, who was the backbone of so much disagreement and disturbance at former meetings of the Council when the electric lighting question was under consideration, on 15th inst., gave further instances of those impetuous and hasty remarks which appear to be characteristic of the speaker. Again, last week, his fellow-members of the Council asked him to set a better example of good behaviour.

The Town Council have advertised their readiness to receive applications for electric lighting, and will be ready to supply electricity after September 30th from dusk to dawn.

Electric Lighting in Ireland.—Electric lighting is progressing rather satisfactorily in County Antrim, Ireland, Messrs. J. Ferguson & Co., of Ballymena, are at present engaged upon orders from Cullybacky Finishing Co., for the fitting up 360 16-C.P. incandescent lamps, dynamo, &c.; also for the supplying and fitting up for the Braidwater Spinning Company, Limited, of two dynamos and about 600 16-C.P. incandescent lamps. One of these latter machines will be driven by turbine water-wheel, for which Messrs. Ferguson have also the contract. The other dynamo will be driven by steam engine. We understand that this will be about one of the largest installations in that part of the country. The Brush Electrical Engineering Company are supplying the dynamo. Messrs. Ferguson have already completed a number of local electric light and telephone installations.

Hove Town Hall Lighting.—The sanction has been given to the borrowing of £1,400 for electric lighting the Town Hall. The money has to be repaid within ten years. At the last meeting of the commissioners it was stated that they had hoped that at least twenty years would be allowed, but there was no help for it, but to accept the terms the Local Government Board would give them. The estimated cost of the current per annum was £200, and the estimated cost of repayment of loan and interest was £165 per annum, making a total expenditure of £365 for electric lighting. The average cost of gas was £152 a year; consequently the excess of electric lighting over gas lighting would be £213 a year. This was assuming the loan would have to be repaid with interest within ten years. After considerable discussion the commissioners by 13 votes to 10 resolved to have the undertaking proceeded with.

Church Lighting.—Final arrangements have been made for the illumination of Ward Chapel, Dundee, by electric light. All the present gas standards are to be replaced by electric light standards. The pulpit is to be lit up by means of two lamps of 32-C.P., and in the body of the chapel 44 lamps, each of 16-C.P., will be fitted up. In the gallery there will be 36 lamps of 16-C.P., while 10 similar lamps will be placed in the organ gallery. The entrance to the chapel will be illuminated by two 50-C.P. lamps, and two others of these lamps are to be fitted up on the stairs. The work, which is expected to be completed in the course of three weeks, has been entrusted to Messrs. Lowdon Bros., Commercial Street, Dundee, a firm which is at present fitting up over 3,000 lamps in various works in the city and district.

Portsmouth Electric Lighting.—The Electric Lighting Committee of the Portsmouth Town Council have issued notices setting forth the conditions under which the Corporation will undertake to supply premises within the specified area with electricity, either for illuminating or other purposes. The streets in which the electric mains of the Corporation will be immediately laid are as follows:—Commercial Road, from All Saints' Church southwards; Cambridge Road, High Street, Hampshire Terrace, Landport Terrace, King's Road, Elm Grove, King's Terrace, Jubilee Terrace, Belle Vue Terrace, Southsea Terrace, Western Parade, Osborne Road, Palmerston Road, Edinburgh Road, Queen Street, Camden Alley, Half-Moon Street, and the Hard; 6d. per unit is to be charged.

Ayr and Electric Lighting.—At the last meeting of the Council a member asked what was being done in connection with the electric light. He thought their policy was a dog in the manger one; they were not doing anything themselves nor yet allowing any other body to do anything. There was a slight flash of electric light in April last, but they had relapsed into darkness again. In reply, it was thought that in this matter delay was the wisest policy. If the inhabitants came forward and said they would like the electric light, they were prepared to take action immediately, but until something of the kind was done, they thought it would be wise to hold on. At the same time he certainly would deprecate letting the provisional order pass out of their hands.

Ullathorne & Edmondson.—This firm, of Bradford and Leeds, are very busy just now on electric lighting work. Amongst the work on hand is the contract for fixing for Messrs. Joseph Benn and Sons, of Great Horton, a 1,250 light "Globe" dynamo and 1,000 16-C.P. lamps, also extensions at their Clayton Mills, comprising 100 16-C.P. lamps. For the Doncaster Co-operative Society, they are fixing a 20 H.P. Crossley Otto engine, a 500 light dynamo, and 24 arc lamps, as well as 150 16-C.P. incandescent lamps. Further, they are fitting up for Messrs. Jennens, Welsh & Co., of London and Huddersfield, a dynamo for 200 lights and 150 16-C.P. lamps.

Personal.—Mr. Robert T. Turnbull on 17th ult. resigned his positions in New Zealand with the Gulcher (New) Electric Lighting Company, and the New Zealand Electrical Syndicate, Limited, and has commenced practice on his own account at Custom House Quay, Wellington, N.Z.

Mr. C. A. Hemingway, who for the last seven years has been in the employ of Messrs. Drake and Gorham, electrical engineers, of 66, Victoria Street, Westminster, has now severed his connection with that firm, and has commenced business as electrical engineer at 10, Petersham Road, Richmond, Surrey.

Electric Lighting Extensions at Huddersfield.—The electric lighting scheme originally provided for the supply of electrical energy for the purpose of illumination to the central business part of the town. In consequence of the numerous demands for supplies to residences in the Edgerton district, mains are now being laid there. A number of buildings have lately been fitted with the necessary appliances for electric lighting. These include the Technical School and the Borough Club, the installation at the latter place having been completed within the present month. About 80 incandescent lights are supplied.

Newtown and Electric Lighting.—The Local Board have received a report from some electricians on the subject of lighting the town by electricity. A committee who considered the subject, stated that although they saw there would be many advantages it could not be adopted at present, because it was probable great strides would be made in the science, and electric light would probably become much cheaper, and they would be able to get better terms from the Gas Company, both as regarded the prices paid by the Board and by the small consumers. This report has been adopted.

Electric Light at Nottingham Castle.—A visitor to Nottingham Castle has written to a local paper as follows: "Being at the Castle Museum the other night, I was much surprised at the unsatisfactory character of the electric light in the new gallery. As the Corporation are undertaking the supply of electrical energy to the town for lighting purposes, they should surely see that in an advertisement of this kind, every revolution of the gas engine be not recorded in the glow lamps, thus producing the rhythmical variation in the intensity of the light, which is so injurious and unpleasant to the eye."

Altrincham Electric Lighting.—In connection with the introduction of the electric light into the town, Messrs. J. Hamilton & Son, contractors, on Monday commenced to lay the service pipes in George Street. The lighting of the town by electricity had been entrusted to the Edison-Swan Company, of Manchester, and Mr. Stanley P. Fairhurst is superintending the George Street section on their behalf. The work is the first portion of a scheme which included the erection of plant at Broadheath, and the extension of the system to Rowdon and parts of Dunham Massey.

Haddon Hall Temporary Electric Lighting.—This historic mansion of the Duke of Rutland's has just been the scene of a large demonstration in connection with the Matlock, Buxton, and Bakewell Habitations of the Primrose League, and the arrangements for the temporary lighting were entrusted to Messrs. Drake and Gorham. Four Crompton-Pochin arc lamps were placed on the towers of the Castle, which afforded light at a considerable distance in the extensive grounds. The effect of the light was very good, and everything passed off in a highly satisfactory manner.

Weston-super-Mare and Electric Lighting.—At a meeting of the Inspection Committee on the 11th inst., Mr. Goode, of Messrs. John Fowler & Co., of Leeds, waited on the committee to state that he would be willing to prepare and submit a scheme and estimate for fitting up an electric lighting station, and laying down plant within the compulsory area. The committee explained that as the Board were now in negotiation with the Brush Electrical Engineering Company, Limited, they could not at the present time give his firm any instructions in the matter.

The National Telegraph Works Company, Limited.—A general meeting of the members of the National Telegraph Works Company, Limited, will be held at 34, Waterloo Street, Birmingham, on October 27th, 1893, at four o'clock in the afternoon, for the purpose of having an account laid before them by the liquidator, showing the manner in which the winding up of the said company has been conducted, and the property of the company disposed of, and of hearing any explanation that may be given by the liquidator.

Paignton and the Electric Light.—At a recent meeting of the Local Board, a letter was read from Messrs. S. D. Williams and Co., of Newport, Mon., asking if the Local Board would be in a position to go into the question of electric lighting. If so, in return for the concession, they were prepared to provide and work the necessary plant. A letter from the general manager of Woodhouse and Rawson United, Limited, of London, was also read. The letters were referred to committee.

Electric Lighting of Brewery Offices.—Some new offices attached to Lady's Well Brewery, Cork, which have lately been completed, are fitted up with electric light. The work was carried out by Mr. Percival of Cork. In the main office there is a fine display: 104 pendant lamps of 150 candle-power each disposed in three rows. Six 32-candle-power lamps are provided over the principal desk, and the ties of the roof are ornamented by cluster brackets. Eighteen candle-power lamps are utilised in this manner and the result is an even distribution of the light throughout the office. The length of the cable and wire used is about two miles. Mr. Percival is also responsible for the telephonic arrangements, and the work has been carried out most satisfactorily.

Pavilion Lighting.—The pavilion in which a ball was held at South Hetton last week to celebrate a wedding festivity, was lighted by 21 electric lamps, fitted by Messrs. F. Reid, Ferens & Co., of Westgate Road, Newcastle. This firm is also engaged in fitting up the Haswell Co-operative Stores with about 200 lamps, with accumulators worked by a dynamo and gas oil engine, and also 300 incandescent lamps and 8 arc lamps with two dynamos at Eppleton Colliery.

Beckingham and Electric Lighting.—At a recent meeting of the Local Board a, letter was read from the Crystal Palace District Electric Supply Company, Limited, stating that their mains were now laid through the Crystal Palace Park Road and Lawrie Park Road and Charleville Circus, within the district comprised by the Local Board, and asking whether the board was prepared to entertain proposals for lighting the localities in question by electricity.

Cambridge Central Station.—In our description of this station a few weeks' ago, we stated that at the colleges there were about 2,000 lamps in use, and that these comprised the majority of the lamps connected to the company's mains. We are, however, asked to state that the total number is about 7,500 lamps, the larger proportion being made up by shop and dwelling-house installations. The figure 2,000 for the colleges was correct.

W. H. Baughan & Co.—A new instrument is being put on the market by this firm, which they call the Unique Combined Wall and Table Telephone. Its chief feature is that as it has the bell on the front it can be hung against a wall or stood on a table or desk. The instruments are so low in price that in many instances they would cost less than the ordinary speaking tubes, which are in many ways objectionable.

Dunoon and Electric Lighting.—A meeting of the Burgh Commissions is to be held on Monday, October 2nd, for the purpose of considering an application of the Caledonian Electric Light Supply Company, Limited, for consent to apply to the Board of Trade for provisional order authorising them to supply electricity. It is said that the application is likely to be granted.

Camberwell and Telephonic Communication.—Telephonic communication is to be established between the Camberwell Vestry Hall and Addington Square, Victoria Road and Park Road depôts, and also inter-communication between the said depôts, at the cost of £35 12s. 6d., on a three years' agreement with the National Telephone Company.

Electric Light at Lambeth.—Mr. W. H. Preece has written to the Lambeth Guardians in reply to their enquiry as to the probable cost of supplying two boilers for electric lighting purposes, estimating the outlay, including setting, at £800. The letter has been ordered to stand over until the subject comes up for reconsideration at the next meeting.

Woolwich Electric Light Supply.—The Local Board have agreed to accept four days' notice as sufficient for disturbing the streets to lay on a supply of the electric light to the shops. The board had legal power to require a month's notice, but the company regarded this as too long for their customers to wait for a supply of light.

Agency.—Messrs. Lotz, Abbott & Co., of 144, High Holborn, have been appointed sole agents for Great Britain and the Colonies, and also for the United States, for the sale of Pittler's universal lathe. A number of these machines of various sizes and styles are on show in practical operation at the above address.

Salford Electric Lighting.—A Local Government Board Enquiry was held on 19th inst. into the Corporation's application for sanction to borrow £50,000 for electric lighting purposes. It was stated that the works are expected to be completed six months after the application has been sanctioned.

Oldham Electric Lighting.—A member of the council asked recently that the lighting by electricity of the monumental lamp in the Market Place should be taken into consideration.

Ediswan Lamps.—The Edison & Swan United Electric Light Company announce that the prices of their ordinary and special lamps will be reduced 2s. each on and after this date.

Electric Light at Dudley.—The Reform Works, Wellington Road, are being fitted up with the electric light. The Brush Electrical Engineering Company have the contract.

Brechin and Electric Lighting.—Inquiries as to the introduction of electric lighting are to be made by a committee of the Police Commission.

Advance in Copper Wire.—The price for high conductivity copper wire on 14th inst. advanced ¼d. per lb.

Electric Pumping Plant.—A test was made on Saturday last, at the works of Messrs. Ernest Scott & Mountain, Limited, Newcastle, of an electric pumping plant which the firm has constructed for Shilbottle Colliery.

Normanby and Electric Lighting.—The Local Board are considering the question of introducing electric light into their district.

CITY NOTES.

Rockhampton Gas and Coke Company, Limited.—The following is an abstract of the report of the directors for the half-year ended June 30th, 1893:—"Taking everything into consideration the directors have reason to congratulate the shareholders upon the satisfactory results of the past half-year. With the gloomy and unprecedented state of financial matters characterising the past few months, and the consequent depression and insecurity in commercial affairs generally, the directors had somewhat feared the company would have felt the effects very much more seriously than it has done. The gas operations show a profit of £1,940 14s. 9d. The electric light operations show an actual loss of £115 15s. 5d., to which is added £289 13s. 7d. interest upon the capital involved in the electric light plant and buildings, &c., making a debit balance in all of £414 9s. The net profit for the whole of the company's business is, therefore, £1,526 5s. 9d. A great improvement appears in the electric light revenue as compared with that of the preceding half-year, while the working expenses are much reduced. The number of customers for the light is increasing, and public lighting with high power arc lamps will be inaugurated on the Fitzroy Bridge in the course of a few months. In view of the large sum vested in the gas interests the directors have thought it inadvisable to push the electric lighting operations, but have preferred to allow this portion of the company's business to expand on its own merits and in response only to unsolicited applications for the light. The directors anticipate being able to report an actual profit upon the electrical business at the next meeting of shareholders. The gas consumption for the half-year is slightly below that of the corresponding period of last year, but every attention is being directed to the extension of this section of the company's business, and particularly in those outside and scattered districts where the gas mains are already laid but, comparatively speaking, little used. Special concessions will be made in such districts to induce the residents to become consumers of gas. Of the new shares recently issued, 2,782 have been taken up. A premium of 30s. per share has been realised upon three hundred of these, and the amount, less incidental expenses in connection with the new shares, has been placed to the credit of a special reserve fund which has been established for the equalisation of dividends. The directors recommend the payment of a dividend at the rate of 10 per cent. per annum, amounting to £1,724 18s. 2d., which will necessitate the appropriation of £200 of the reserve fund for equalisation of dividends. You will be called upon to elect two directors in the place of Messrs. F. A. Morgan and C. McVeigh, who have both offered themselves for re-election, and to elect two auditors in the place of Messrs. G. H. Jones and H. W. Boldeman, who also offer themselves for re-election. The accounts contain the following items under the heading of assets:—

	£	s.	d.
Overhead Electric Light Mains	83	2	5
Electric Light Plant	6,728	16	1
Electric Light Fittings on Rental	256	11	3
Electric Light Fittings in stock	771	15	11
Freehold Buildings (Electric Lighting Works)	1,596	5	6
Freehold Land, Alma Street	900	0	0

Under the profit and loss account appear the following items:—

	£	s.	d.
By Electric Current Sales	409	2	6
„ Sundries	87	12	2
„ Electric Light Fitting Account	78	13	8
„ Balance	414	9	0
	£989	17	4

Eastern Extension, Australasia, and China Telegraph.—The directors have declared an interim dividend for the quarter ended June 30th, of 2s. 6d. per share.

Globe Telegraph and Trust.—The directors have declared an interim dividend of 1s. 6d. per share.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending September 17th, 1893, amounted to £756; week ending September 18th, 1892, £744; increase £12; total receipts for half-year, 1893, £8,880; corresponding period, 1892, £8,440; increase £440.

The Western and Brasilian Telegraph Company, Limited. The receipts for the week ending September 15th, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brasilian Telegraph Company, Limited, were £1,220.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Issue.	Name.	Stock or Share.‡	Closing Quotation September 13th.	Closing Quotation, September 20th.	Business done during week ended September 20th, 1893. Highest.	Lowest.
184,500£	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	...	...
1,134,640£	Anglo-American Telegraph, Limited	Stock	50 — 51	50 — 51	50⅜	...
2,932,680£	Do. do. 6 p. c. Preferred	Stock	92½ — 93½	92 — 93	93½	92½
2,932,680£	Do. do. Deferred	Stock	9⅜ — 10⅛	9⅛ — 10	10⅛	9 1/16
130,000	Brazilian Submarine Telegraph, Limited	10	11⅛ — 12	11⅛ — 12	12	11⅜
18,700£	Do. do. 5 p. c. Bonds	100	99 —103	99 —103	100½	...
75,000£	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	107 —111	107 —111	...	...
77,978	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	2⅞ — 3⅛	2⅞ — 3⅛	3 1/16	2⅞
75,000	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	2⅛ — 2⅜	2⅛ — 2⅜	2 9/16	2⅛
125,000£	Do. do. 4½ per cent. Debenture Stock	Stock	106 —108	106 —108	107½	106⅜
20,510	Charing Cross & Strand Electricity Supply Nos. 1 to 6, 215 to 718, and 10,001 to 30,000	5	5 — 5½	5 — 5½	...	...
44,000	Chili Telephone, Limited, Nos. 1 to 40,000	5	2 — 3	2 — 3	...	...
630,000£	City and South London Railway	Stock	35 — 37	35 — 37	...	...
40,000	City of London Elec. Lighting Co., Ltd., Ord. 40,001-80,000 ...	10	11½ — 11⅝	11½ — 11⅝	...	...
20,000	Do. do. 6 p. c. Cum. Pref., Nos. 1 to 20,000	10	12½ — 13	12½ — 13	13	12⅝
$7,716,000	Commercial Cable, Capital Stock	$100	127 —132	135 —140 xd	...	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	10/-	1/16 — 3/16	1/16 — 3/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Cum. Pref. Shares, Nos. 1 to 20,000	5	3½ — 4½	3½ — 4½	4⅜	4¼
50,000£	Do. do. 5 p. c. 1st Mort. Debs., 1—400 of £100, and "A" 1—200 of £50 each	...	98 —102	98 —102	...	...
16,000	Cuba Telegraph, Limited	10	11 — 12	11 — 12	11⅛	...
6,000	Do. do. 10 p. c. Preference	10	18 — 19	18 — 19	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	2½ — 3½	2½ — 3½xd	...	...
6,000	Do. do. 10 p. c. Preference	5	8½ — 9½	8½ — 9½xd	...	...
60,710	Direct United States Cable, Limited, 1877	20	11⅛ — 11⅜	11⅛ — 11⅜	11⅜	11⅛
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	15 — 15½	15 — 15½	15½	15 1/16
70,000	Do. 6 p. c. Preference	10	16 — 16½	16 — 16½	...	...
105,900£	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	106 —109	106 —109	...	...
1,294,100£	Do. 4 p. c. Mortgage Debenture Stock	Stock	111 —114	111 —114	114	112½
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	15⅛ — 15⅜	15⅛ — 15½	15½	15 3/16
62,700£	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	102 —105	102 —105	...	...
222,800£	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	102 —105	102 —105	...	...
320,000£	Do. 4 p. c. Debenture Stock	Stock	110 —113	110 —113	110½	...
108,700£	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	100 —103	101 —104	...	...
146,800£	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	101 —104	101 —104	...	...
300,000£	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	100 —103	101 —104	102¼	101⅜
200,000£	Do. 4 p. c. Reg. Mt. Debs. (Mauritius Subsidy) 1 to 8,000	25	103 —106 %	103 —106 %	104⅛	104
49,900	Electric Construction, Limited, Nos. 101 to 45,100	10	1⅛ — 1⅜	1⅛ — 1⅜	1 1/16	1 1/16
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	... ...	... ...	...	...
100,000	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	⅛ — ¼	⅛ — ¼	...	...
91,195	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	⅛ — ⅜	⅛ — ⅜	⅜	...
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	⅛ — ⅜	⅛ — ⅜	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	1 — 2	1 — 2	...	...
180,227	Globe Telegraph and Trust, Limited	10	9⅜ — 9⅞	9⅜ — 10	9⅞	9⅜
150,042	Do. do. 6 p. c. Preference	10	15½ — 15⅝	15½ — 15⅝	15⅝	15 5/16
150,000	Great Northern Tel. Company of Copenhagen	10	19⅜ — 20¼	20 — 20⅛	20⅛	19 15/16
200,000£	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	103 —106	103 —106	...	...
12,134£	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	4½ — 5½	4½ — 5½	...	...
9,600£	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	6 — 7	6 — 7	...	...
50,000	India-Rubber, Gutta Percha and Telegraph Works, Limited ..	10	21½ — 22½	21½ — 22½	22 3/16	22
200,000£	Do. do. 4½ p. c., Deb., 1896	100	102 —104	103 —105	...	...
17,000	Indo-European Telegraph, Limited	25	39 — 42	39 — 42	40½	39½
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	1 — 2	1 — 2	...	...
30,000	†Liverpool Electric Supply, £3 10s. paid	5	4⅛ — 4¼ xd	4⅛ — 4¼xd	4 1/16	4 1/16
10,000	Do. do. fully paid	5	6 — 6¼ xd	6 — 6¼xd	6⅛	5⅞
37,500	Liverpool Overhead Railway	10	... — ...	5½ — 5⅝	8⅛	4⅜
37,548	London Platino-Brasilian Telegraph, Limited	10	4 — 6	4 — 6	...	...
100,000£	Do. do. do. 6 p. c. Debentures	100	104 —107	105 —108	...	...
49,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	6½ — 7	6⅝ — 7¼	7	6½
50,000£	Do. 5 p.c. debentures, 1 to 5,000 in bonds of £10, £20, £40	...	104 —107	104 —107	106	105¼
15,000	Monte Video Telephone Co., Ord., Nos. 1 to 15,000 fully paid ...	5	1⅞ — 2⅛	1⅞ — 2⅛	...	...
28,000	Do. do. 6 p. c. Pref., Nos. 1 to 28,000 fully paid	5	3 — 4	3 — 4	...	...
458,867	National Telephone, Limited, Nos. 1. to 438,984	5	4⅜ — 4⅝	4⅛ — 4⅜	4⅜	4⅛
15,000	Do. 6 p. c. Cum., 1st Preference	10	14½ — 15½	14 — 15	14 13/16	14⅝
15,000	Do. 6. p. c. Cum. 2nd Preference	10	14 — 15	13½ — 14½	13⅝	...
90,950	Do. 5 p. c. Non-cum. 3rd Pref., Nos. 1 to 90,950 ...	5	5¼ — 5½	5⅛ — 5⅜	5 1/16	...
726,477£	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	111 —113	112 —114	113¼	112½
48,800	New Telephone, Limited, Nos. 25,901 to 74,700 ... (£2 paid)	10	... ...	... ...	...	...
6,452	Notting Hill Electric Lighting Company, Limited, fully paid ...	10	5 — 6	5 — 6	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	1/16 — 1/16	1/16 — 1/16	...	...
100,000£	Pacific and European Tel., Ltd., 4 p. c. Guar. Debs., Nos. 1 to 1,000	100	100 —103	100 —103	102	...
11,802	Reuter's Limited	8	4½ — 5½	4½ — 5½	...	...
19,980	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	6½ — 7	6¼ — 6⅜	...	...
20,000	Do. do. 7 per cent. pref., Nos. 20,081 to 40,080	5	8 — 8½	8 — 8½	...	...
3,381	Submarine Cables Trust	Cert.	115 —120	115 —120	118½	117
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	2 — 2⅛	2 — 2⅛	...	...
37,350	Telegraph Construction and Maintenance, Limited	12	32 — 34	32 — 34	33⅜	33
150,000£	Do do. do. 5 p. c. Bonds, red. 1894	100	101 —104	101 —104	...	...
58,000	United River Plate Telephone, Limited	5	2 — 2⅛	2 — 2⅛	...	...
146,370£	Do. do. 5 p. c. Debenture Stock ...	Stock	90 —100	90 — 100	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	5½ — 6½	5½ — 6½	...	...
260,900£	Do. do. do. 5 p. c. Debentures	100	97 —100	97 —100	99½	...
30,000	West Coast of America Telegraph, Limited	10	2 — 3	2 — 3	...	...
150,000£	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	97 —101	97 —101	100	...
64,242	Western and Brasilian Telegraph, Limited	15	6½ — 7	6½ — 7	...	...
33,129	Do. do. do. 5 p. c. Cum. Preferred	7½	5⅜ — 6¼	5⅜ — 6¼	...	...
33,129	Do. do. do. 5 p. c. Deferred	7½	1¼ — 1⅜	1¼ — 1⅜	...	...
178,200£	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	...	...
222,700£	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	...	..
88,321	West India and Panama Telegraph, Limited	10	1½ — 1⅝	1½ — 1⅝	...	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	10¼ — 10⅜	10¼ — 10⅜	...	...
4,669	Do. do do. 6 p. c. 2nd Preference ...	10	9 — 10	9 —10	9⅜	...
80,000£	Do. do. 5 per cent debentures (1917) No. 1 to 1,000	100	106 —109	106 —109	...	...
$1,214,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	115 —120	115 —120	118	117½
169,000£	Do. do. 6 p. c. Sterling Bonds	100	101 —104	101 —104	...	...
59,900	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953 ...	5	4⅜ — 5½	4⅜ — 5½	5	4⅞

* Subject to Founders' Shares. † Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED:—Birmingham Electric Supply Company, Ordinary of £5 (fully paid), 5—5½.—Brush Company, 4½ per cent. Debenture Stock, issued at 1 per cent. premium, 100—103.—Electric Construction Corporation 6 per cent. Debentures, 95—98.—Electric and General Investment, shares of £5 (£1 paid), 1⅜—2⅛.—Founders' shares, 200—225.—Electricity Supply Corporation, Ordinary of £5, 5—5⅛.—House to House Company (£5 paid) 1⅛—2⅛.—Do. 7 per cent. Preference of £5, 5—5⅛.—Do. 6 per cent. Debentures of £100, 97—102.—Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid), 5⅜—5⅝, 1st Preference Cumulative 6 per cent., £5 (fully paid) 5—6⅛.—Manchester, Edison and Swan Company £9 (£1 paid), 4—4⅛.—Queen Anne's Mansions Lighting and Heating 6 per cent. £100 Debentures, 101—103.

Bank rate of discount, 4 per cent. (September 14th, 1893.)

ELECTRICAL ENGINEERING AT THE WORLD'S FAIR.

XII.

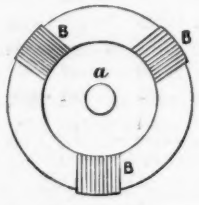
FOREIGN exhibitors at Chicago have in their way done better for the Exhibition than the native exhibitor.

Messrs. Siemens & Halske have two exhibits, both of which must, if studied by the American electrician, prove quite a liberal education for him, both in the matter of history and in the design of electrical machinery.

European electricians have already seen, at prior exhibitions, most of the interesting things exhibited. Their electric car motor for three-phase currents is the only novelty in car motors in the Exhibition. The connections from the field windings come to a switch, by means of which the driver can couple the winding as a star wind or as a triangle wind. As a star, the power is only 20 horse-power, and the speed one-third of the maximum speed. As a triangle, the power is 60 horse-power and the speed three times that of the star coupling.

The Siemens three-phase transformers are here shown also. They consist of three laminated iron bars arranged with a closed magnetic circuit. This magnetic circuit is constructed as shown in the figs. 1 and 2. Fig. 1 is a plan, and fig. 2

FIG. 1.



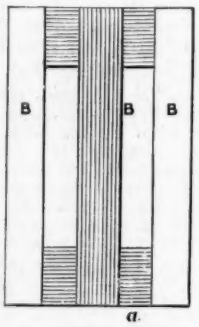


FIG. 2.

an elevation. The two yokes, *a*, are built of discs of soft iron, and the cores, B, are built of soft iron strips.

A primary and secondary coil is slipped over each core. Two transformers built like this are shown, each of 50 units capacity.

This exhibit also contains an instrument for measuring very short intervals of time within ·000002 second. By means of this instrument the velocity of cannon balls can be measured.

Wire gauze resistance frames are also shown here. The resistance is made up of broad strips about 6 inches wide, of brass wire gauze; the large surface exposed by the gauze, and the free circulation of air through it, renders them capable of dissipating a large quantity of heat.

In the upper gallery Siemens have another exhibit, principally of historical machines; this exhibit was not finished, nor open for inspection, before the middle of August. The Siemens original dynamos and motors, so familiar to the reader of books on electricity, are all here, and form a very interesting show for the Americans to study.

The Allgemeine Electricitäts Gesellschaft have an extensive display of three-phase generators and motors, all of which have been fully described before. A liquid switch for starting and stopping high pressure motors is shown here; it consists of two cells filled nearly up with a solution of caustic soda; these are connected in series by a ∩-shaped strip of iron, which is dipped into the liquid when it is desired to close the circuit. In the operation of closing, the tips of the two legs first touch the surfaces of the liquid, and as they are further immersed offer less and less resistance, until they are finally short-circuited by a metallic contact.

In turning off the current the short circuit is first broken, and then the ∩-shaped iron is gradually withdrawn, offering more and more resistance, until the circuit is finally broken by the withdrawal of the iron from the soda solution.

Hartmann & Braun, of Frankfort, have an exhibit almost entirely enclosed in a sort of pavilion with heavy-curtained entrances. By these means the daylight has been almost entirely excluded; so much so, that the exhibits can be very indistinctly made out to be there; but no details can be seen except at night, when the electric light is turned on.

The exhibition authorities have allowed too much of this building up of enclosures. In the electricity building every company of any size has built up an entirely closed building; no doubt they are excellent examples of the plasterer's art, but the general effect of the exhibits is entirely spoiled.

To enumerate the great display of plaster building occupying so much space in the electricity building, there is right in the centre a tall shaft with a colonnade at the base; the whole thing looks like a factory chimney, but it is called a German Tower of Victory; the shaft is covered by small incandescent lamps, which can be switched off and on in groups "in a manner that holds all spectators spellbound," as the American reporter puts it. At the top of the "Tower of Victory" the memorable inscription is to be seen in words of fire, "Edison Light" and "General Electric Company."

The Brush Company have a plaster building which they call a "Handsome Corinthian Temple," with a dome roof handsomely frescoed.

The Western Electric Company have what they call the handsomest feature of their display, "an Egyptian Temple;" they also have a column of lamps.

The American Bell Company have a huge building planted right in front of the doorway of the electricity buildings; it is 103 feet by 67 feet in area. It is euphoniously styled the "Erectheum of Athens." Ionic columns, porticos, tablatures, and other architectural features are noticeable.

The General Electric Company also have a building of large size, not dignified by any Greek name.

Now all these may be considered very ornamental, and that depends a good deal upon taste, but they are certainly worse than useless in an electricity exhibition. Visitors don't go into an electricity exhibit to see plaster models of Corinthian temples, Egyptian temples, pavilions, German towers of victory, &c., and it cannot be denied that their presence detracts very much from the facilities for examining the real exhibits.

The French exhibits are in a fine position on the floor, and are not mixed up with plaster temples or pavilions, but stand open for fullest examination. There is, however, not a single attendant on the French exhibits, and no circulars to be got. The principal exhibit is the Desrozier dynamo, a multipolar machine like the Mordey alternator, with the field fixed, and the armature rotating.

The British exhibitor is conspicuous by his scarcity. The B.P.O. is, of course, the most important in this section. Here, again, is provided a liberal education for the American telegraph engineer, both in the history and in the construction of telegraph apparatus.

The General Electric Company, of London, have also a very fine display of their specialities—fittings, heating apparatus, Aron's electricity meters, and Reckenzaun and Binswanger's meter. It is remarkable that this is the only exhibit containing electric fittings in the whole show. In the spaces allotted to Great Britain, but not occupied by electricity exhibits, a shanty has been erected to exhibit "Meyer's patent ballot machine." A placard informs the visitor that "no electricity is used." Another exhibit, "where no electricity is used," is also in the British section, that of the Homacoustic Apparatus Company, showing speaking tubes.

There are other exhibits where "no electricity is used" in other sections of the "Electricity Buildings." One-half of one of the huge galleries in the building is occupied by pianos, organs, and other musical instruments, while there are sundry exhibits of surgical instruments, and several automatic machines hatching chickens, and three exhibits of quack electrical belt and battery fakirs.

Deducting empty spaces, spaces occupied by plaster buildings, and exhibits where "no electricity is used," there is not much space covered by the actual exhibits of interest to the electrician

CENTRAL ELECTRIC LIGHT STATIONS.

No. 12.—GLASGOW ELECTRIC LIGHT SUPPLY.

THIS station has been erected by the Corporation of Glasgow entirely from designs prepared by Prof. A. B. W. Kennedy, F.R.S., consulting engineer to the corporation. The area of supply, under the provisional order, is about two square miles; but so great has been the success attending the introduction of the electric light in this district, that arrangements are now being made to lay mains in districts outside the area of supply authorised under the provisional order. Already 31,000 8-C.P. lamps are being supplied, and applications for the light continue to be received at the rate of about 420 lamps per week.

The plant consists at present of five of Lindsay, Burnett and Co.'s single ended marine boilers, Willans engines, coupled direct to Latimer Clark & Muirhead dynamos, a Crompton-Howell 500 ampère-hour storage battery of 116 cells, and a small high tension arc lighting plant. Two 80-H.P. generating units, each capable of an output of 400 ampères at 110 volts are used as equalisers. Two 150-H.P. and two 250-H.P., capable respectively of 400 ampères at 220 volts, and 670 ampères at 220 volts are used to supply current for direct supply, or for charging the accumulator. It is intended to remove the arc lighting plant from its present position, and erect two Willans triple expansion (I I I) 400 H.P. (1,000 ampères at 220 volts) in its place.

The boilers do not present any particular feature of interest in themselves, but it is certainly significant that so great an authority as Prof. Kennedy should have reverted to the single ended marine type. It is possible that the powers that be in the centre of the shipbuilding industry would have none of the new fangled land boilers. It is more probable that water-tube boilers have not proved so satisfactory in general work under the conditions obtaining at a central electric supply station. At first sight it is almost obvious that the Cornish or Lancashire boiler is better adapted to the variations in demand in generating centres on the ground of economy, than boilers of the water-tube type.

The instruments used are, for the most part, of Lord Kelvin's design. Lord Kelvin's latest form of meter is receiving a great deal of attention in the laboratory attached to the station, and is being carefully tested. It would be premature to give any results of the tests, but it may be said that the performance of the meter is satisfactory.

The arrangements for testing the mains are exceedingly simple, and the switchboard and means of regulating the E.M.F. of the machines reflects great credit on the gentleman responsible for the arrangement. The switchboard is erected at a height of about 8 feet above the floor at one end of the engine-room, thus giving the engineer on watch an excellent view of the machinery. The usual arrangements exist for switching machines in and out of any or all circuits, but on the handrail running round the platform in front of the switchboard are placed the sliding blocks and contacts of the variable resistances inserted in the shunt of the various dynamos. This enables a careful man to maintain almost perfect regulation, as the sliding blocks can be operated without removing the eye from the voltmeters showing the potential at the feeding points. The daily potential charts taken from the recording voltmeters show that these facilities for regulation have been taken the fullest advantage of, and the very few serious kinks in the line reflect great credit on Mr. Norman Macfarlane, the resident engineer, and on the members of his staff. It appears that a few of the larger consumers are still in a state of mind bordering upon childish delight, which characterises most new consumers of electric light; that is to say, they are not yet tired of turning a great number of their lamps off and on suddenly, "just to see what the other lamps do." One large consumer used to play with 150 ampères, but he was politely remonstrated with, and has (fortunately for Mr. Macfarlane's peace of mind) refrained from treating the electric supply like a new toy.

The dynamo circuits are protected by magnetic cut-outs and also by fuses. The gear for operating end cells of the battery is placed on the switchboard, but the switches are placed in the accumulator room. The conductors from the switchboard to the accumulator room and throughout the engine room, consist of solid copper rods on insulators supported by iron brackets fixed in the wall. The negative conductors are painted red and the positive black. As the positive ends of accumulator cells are painted red, it would appear at first sight unnecessary to have departed from this custom. The only assignable reason is that in pole finding paper the negative main leaves a red mark. But as it is just as easy to prepare paper which would cause a red mark to appear on the positive main, it would, perhaps, have been better to alter the pole paper accumulators and red colour for positive leads are much older than pole finding paper.

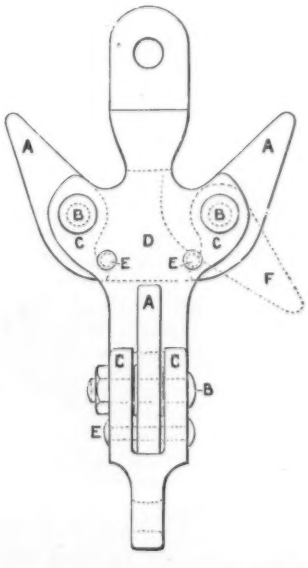
The station has only been open a few months, and is still unfinished as far as much of the office and laboratory equipment is concerned, but everything is being rapidly pushed forward, and before very long there will be a very complete laboratory fitted with all the necessary instruments for carrying out tests of incandescent and arc lamps, and a very ingenious system of plug and fork switches, enabling electric energy for testing purposes to be used at a current density and E.M.F. capable of variation over a considerable range.

The system of distribution is the three-wire with feeders, and a separate high-tension circuit is run for the arc lighting, 50 arc lamps being connected in series.

We are much indebted to Mr. Norman Macfarlane, resident engineer, and to other members of the staff, for their courtesy in showing our representative the chief points of interest in the station.

STALLIBRASS'S SUBMARINE CABLE GRAPNEL.

THIS grapnel, which is shown by the fig., is provided with four, or other convenient number of toes, A, preferably in pairs opposite each other, as shown, each pivoted at B, between cheeks, C, formed in the shank, D, of the grapnel. Or the cheeks may be formed at the base of the toes and fit over shoulders in the shank of the grapnel. Each toe is maintained in its normal upward position by a pin of soft iron or its equivalent, E, which is passed through the checks.



Should a toe foul a rock, or other obstruction, upon the strain on the grapnel rope reaching to, say, three tons, the pin, E, will be broken away allowing the toe to capsize as shown in dotted lines at F, and free itself of the obstacle. A broken pin can be readily replaced, and it will be understood that its size or temper may be varied so that it shall break approximately at any predetermined strain.

A toe when capsized projects further than it does when in its normal position, and, its direction being reversed, has the effect of turning the grapnel over, whereby the disadvantage of its being towed with its disabled side downwards is avoided.

HOOPER'S CORE FOR SUBMARINE CABLES.

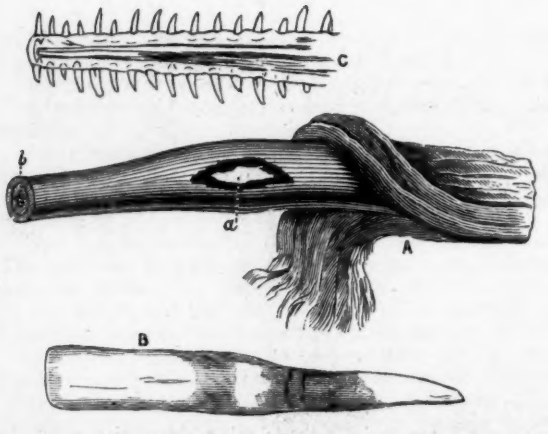
IT is now a matter of history that several of the cables made and laid by the firm of Hooper's Telegraph Works, Limited, met with very poor success, while cables, the cores of which were made by Mr. Hooper in 1866 and onwards, though sheathed by other manufacturers, continue to give general satisfaction. This is the more remarkable, as one would have thought that from the experience necessarily acquired, the later manufactured cables would have been more reliable. It is nevertheless a fact that the cables laid on the Brazilian coast, with the exception of the shore ends, and a portion laid in the deep sea, have not fulfilled the expectations of the contracting parties; in fact, the whole of the Pará, Cayenne and Demerara, a line of about 1,000 miles in length, was, after several months' patching up, abandoned by the contractors. The history of this cable forms a heavy item in the list of failures. In this instance the contractors were to be furnished under the contract with accurate and proper soundings, and the engineers of the contracting parties were to mutually agree upon the course over which the several cables were to be laid. The main portion of this cable having been originally manufactured in 1872 to be laid across the Atlantic, being sheathed with nine steel wires, each served with tarred Manilla yarns, had fallen in insulation where tar had been freely used, and was actually laid for the major part of the distance in water averaging less than 50 fathoms, with a current running, at times, 5 knots an hour, and across the mouth of the Amazon and other rivers. The cause of failure in this instance was immediately due to the attacks of the sawfish, though we do not think that a deep sea cable laid in such shallow water could have been expected to maintain communication for any considerable length of time.

The following extract from the late Frank Buckland's "Log Book of a Fisherman and Zoologist," will be found highly interesting:—

INJURY TO A SUBMARINE TELEGRAPH CABLE BY A FISH IN THIRTY FATHOMS OF WATER.

By the kindness of Mr. Latimer Clark, C.E., engineer to the British Indian Extension Telegraph Company, I had submitted to me in June, 1873, a portion of the submarine telegraph cable laid between Penang and Singapore of which the engraving will give a good idea. The drawing is made the actual size of the injured portion of the cable.

A hempen rope, A, is tightly coiled round the gutta-percha portion of the cable. This was, of course, underneath the iron wires which formed the outside of the cable. In the



middle of the gutta-percha, the copper wires are seen embedded at *b*. In the middle of this gutta-percha there is a jagged hole exactly the size and shape of that given in the drawing at *a*. A minute observation of the interior of the wound shows that three of the wires at this point are snapped right across, the broken ends being all thrust in the same direction, viz., *away* from the spectator as he examines the drawing. The remaining four wires (there are seven at the point *b*), however, remain intact. The uninjured wires can be seen at the lower side of the wound, the weapon which made the hole having missed them.

The following information has been kindly furnished by Colonel Glover, R.E.:—

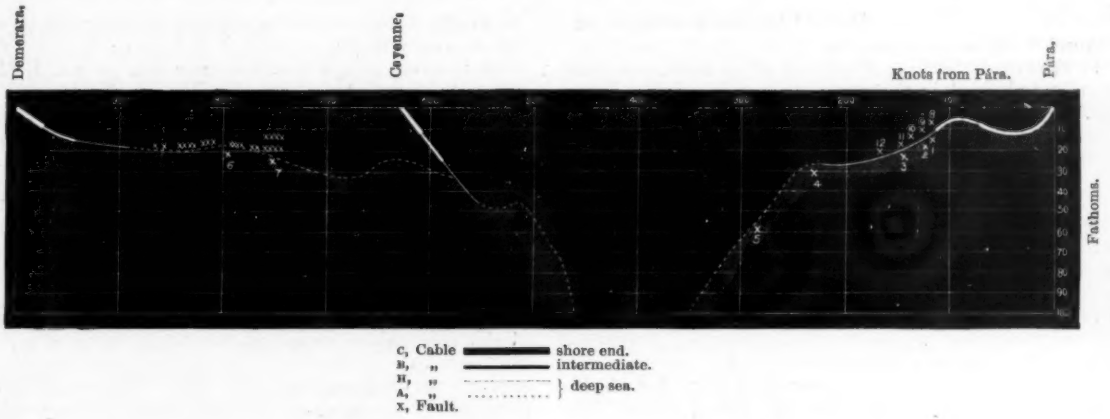
"I really have very little information to give you about the fault in the Penang and Singapore section of our cable. The cable was laid on December 11th, 1870, and its tests were satisfactory. It worked well as far as we know, and we had no reason to suppose anything wrong, when on March 1st, 1871, or three months afterwards, a telegram was sent from Singapore, saying that a serious fault had developed itself, which prevented direct working between Singapore and Madras, and necessitated 'transmission' at Penang. Work was carried on this way for some time, when in June one of our vessels went out, found out the fault and repaired it on June 7th, 1871. After this the tests were satisfactory, and the cable has continued so ever since. The fault was 222 miles from Singapore, and in 30 fathoms of water; the bottom being marked sand and mud. The report which came home to us was that a bony substance had been found jammed hard in the cable through the wires, and it was supposed to have been done before laying. As we could not understand why the original tests should be good if the substance had not existed, and why failure should be sudden, I did not believe this, and on receiving the faulty specimen I went to Willoughby Smith, and we opened it together. The bony substance appeared to us a fish tooth, and probably a shark's, but as no mark of the other jaw appeared we were puzzled, and gave it to you. This is all the information we possess, nor, indeed, can I see how we can get more, as no persons have seen it since."

I confess I was exceedingly puzzled with this most difficult problem. The hole towards the spectator is two-thirds larger than it is on the opposite side. If it had been an ordinary fish, such as a shark, there ought to have been the marks of a bite on *both* sides of the cable, namely, of a tooth in both the lower and upper jaws. This wound, therefore, must of necessity have been made by a fish having but one tooth, and one tooth only, but what fish is there that has only one tooth? For several weeks I kept the specimen on my mantelpiece, and was constantly thinking over the puzzle. At last one day I hit it off all in a minute. On going round my museum I observed with most intense interest a beak or saw of a saw-fish (*Pristis antiquorum*), presented to me by Dr. Day, Inspector of Indian fisheries, the fish having been taken in the Andaman Islands. "That's the fellow," I said to myself, "that made the hole in Mr. Latimer Clark's telegraph cable"; so taking one of the teeth out of the beak of the saw-fish, I placed a spare portion of the telegraph cable on the table and struck the end of the tooth with the mallet, and immediately produced a wound almost, I may say exactly, similar to that found on the Penang telegraph cable. This tooth is seen at B.

My theory is, therefore, very simple, and I think is correct, viz., that the perpetrator of the wound was a big saw-fish. The cable lay quiescent at the bottom of the sea, when one day a saw-fish came by hunting for his dinner. The mode which the saw-fish adopts to get his food is, I believe, by waving his saw horizontally right and left, and turning up the mud or sand in order to dislodge the delicate-bodied marine creatures on which he subsists. His teeth will tell us he cannot eat hard substances. When thus engaged in his submarine digging, the saw-fish suddenly came across the telegraph cable. His beak getting entangled in it, he gave it an extra blow and a smash downwards, and finally getting enraged, hit it so hard that one of his teeth went between the outer wires, through the hempen rope, and then through to the gutta-percha, injuring the wires. These various substances probably then held the tooth somewhat tightly. The fish then struggled and broke his tooth short off, leaving a bit of it actually embedded in the cable among the wires.

I am inclined to think that the saw-fish uses his formidable weapon to stir up the mud in search of his food, because the points of the teeth in the saw, which are composed of a very hard bony substance, are always very sharp, as sharp, in fact, as the tips of a wild boar's tusk, which, as we all know, are kept finely pointed by constant friction.

I have made a section of a tooth of the saw-fish as represented at B in the drawing. The light coloured portion which fits into the blade of the saw is cellular, and presents the structure of a common walking cane. The sharp point will be observed in the engraving. At C there is a small drawing of the entire beak of the saw-fish, and I leave it to



No. 1.—FAULT PICKED UP IN PARA-CAYENNE-DEMERARA CABLE BY SS. *Great Northern*, JULY 1ST, 1875.

No. 2.—FAULT PICKED UP IN PARA-CAYENNE-DEMERARA CABLE BY SS. *Great Northern*, JULY 1ST, 1875.

No. 1.—FAULT PICKED UP IN PARA-CAYENNE-DEMERARA CABLE BY SS. *Great Northern*, JULY 5TH, 1875.

No. 2.—FAULT PICKED UP IN PARA-CAYENNE-DEMERARA CABLE BY SS. *Great Northern*, JULY 5TH, 1875.

the reader to weigh the evidence I have now adduced, and consider if my theory is correct.

I have submitted the small portion of the bone, which was actually embedded in the wound to my friend Mr. Henry Lee, who, after microscopic examination, says, "It is more like the tooth of the saw-fish than anything else." This report agrees entirely with my own observations.

The portion between Pará and Cayenne was completed on July 5th, 1874. The next day, July 6th, it was found that a fault had broken out in the submerged cable; the ss. *Great Northern* left Pará to begin the repair on July 20th; Nos. 1 and 2 faults were removed on July 25th, 1874, and are reported by the supervising engineer as distinct "fish bites"; Nos. 3 and 4 removed on August 1st and August 11th, are reported as due to the same cause, and No. 5, removed on August 27th, was noted as "origin doubtful," probably mechanical injury, and the operations were brought to a close on September 6th, 1874.

The insulation of the cable between Para and Cayenne being then satisfactory, giving 3,000 megohms first minute per nautical mile at 75° F., remained in the same state until October 10th, when a great change was observed during the test then taken. Between October 15th and 16th the cable had parted near the T-piece off Cayenne, and on November 8th the test showed a sudden fault at approximately 116 nautical miles from Pará.

On January 8th, 1875, the ss. *Great Northern* again arrived on the ground to restore communication and remove faults. The length connecting Demerara to the T-piece off Cayenne had been laid on January 22nd, 1875, within nine miles of the T-piece off Cayenne, when a fault suddenly broke out at a point estimated at 200 miles from the ship. Repairs were begun on January 21st, 1875, and continued till March 4th, 1875; the T-piece was repaired, and the cables laid by the first and second expeditions were joined to the T-piece, establishing communication between Demerara, Cayenne and Pará on January 30th. Two faults (Nos. 6 and 7) were first cut out in the cable laid by the second expedition; one of these was found in a position assigned to the fault which appeared during the laying of the cable and proved to be a "fishbite," and two other faults (Nos. 8 and 9 reported as "fishbite" and "injury") were removed on March 1st in the cable laid by the *Great Northern* when repairing in the autumn of the previous year.

Another repairing expedition began to work on May 20th, and continued until July 15th, but the cable was still faulty, though upwards of 20 faults were removed during this expedition. The cable, though faulty, was fit for transmission of messages and continued to work until May, 1876.

Not one of the faults removed could be traced to bad manufacture or to broken wires, but were due to external causes after being laid.

Owing to the abandonment of this cable it was generally thought that the insulated wire, known as Hooper's core, would never be employed again for submarine cables, and recognising the importance of counteracting this impression, Mr. John P. Hooper, after the decease of his father in 1878, determined to prove that the aspersions cast upon the good qualities of his father's core were unfounded.

Some 400 miles of deep sea cable being left in the tanks at Millwall, part of which had been retained as unfit for use, and part having been brought home from various expeditions as surplus cable, the pieces were spliced, and at the end of the year 1877 were tested in three sections by Messrs. Clark, Forde & Co., who thought that they might be used with safety; but it was not until 1880 that an arrangement could be made to utilise the cable, the terms of contract making Messrs. Hooper responsible for the cable for 12 years, including all accidents of every kind, and faults of manufacture, if any, the cable being paid for by yearly instalments.

This cable was laid between Cienfuegos and Santiago for the Cuba Submarine Telegraph Company in February, 1881, and worked without accident until August, 1891, when a break occurred in 500 fathoms, owing to the nature of the bottom; this break was repaired by Mr. Keith in March, 1892.

The present month has seen the expiration of 12 years' working, during which Mr. John P. Hooper, with characteristic courage and "true to the core," guaranteed to maintain the cable. As part of this cable is laid in 3,000 fathoms of water, it proves that the deleterious absorption of water by the core under pressure is a fallacy; it also shows that the core supplied for the cable laid on the Brazilian coast was not to blame for the misfortunes of the cables. It is, moreover, worth knowing, on good authority, that the Great Northern Company are now having resheathed some core 180 lbs. copper, 180 lbs. insulation made in 1868 by Mr. Hooper, and then laid by Mr. Newall between England and Denmark, into a 4½ ton cable for further service; and likewise some core 300 lbs. copper, 200 lbs. insulation, supplied for the China cables in 1869 (both of which test practically the same as when first made, giving upwards of 4,000 megohms first minute per knot at 75° F.), and that the old cable connecting India and Ceylon, laid in 1866, has remained efficient, except where the shore ends have had to be renewed.

Looking to these facts, and seeing that the War Office and the Admiralty have continued to employ this core for their torpedo cables, we cannot but think that in the future Hooper's core is likely to prove a formidable rival to gutta-percha.

ON THE CARRYING CAPACITY OF ELECTRIC CABLES, SUBMERGED, BURIED OR SUSPENDED IN AIR.*

BY A. E. KENNELLY.

THIS paper gives the results of a series of measurements made at the Edison Laboratory on samples of Siemens cable manufactured at Schenectady at the works of the General Electric Company.

The simplest case is that of a solid cylindrical conductor of radius r cms. carrying a steady current of C ampères with a resistivity at the working temperature of a ohms. The conductor is covered to a radius of R cms. with a solid insulating material, closely fitting over which is a tube or cylindrical sheathing of lead or other metal. Calling ρ the electrical resistance of the conductor per centimetre of length, and S the thermal resistance of a body between two surfaces whose difference of temperature is ϑ deg. cent., we have:—

$$C = \sqrt{\frac{\vartheta}{\rho S}}. \qquad (1)$$

This relation determines the limiting current strength for the cable when the radii and resistivity of the insulator are given, and the temperature elevation has been decided upon. The temperature elevation permissible for Siemens cable is 60° C., and may be considered a fair limit, and since the normal temperature of air or soil may reach 35° C. in summer, the safe limit of temperature elevation will be 25° C., or 45° Fahr.

with this value of ϑ in equation (1), $C = \sqrt{\frac{5}{\rho S}}$ (2)

or developing $C = 5\, r \sqrt{\frac{2\pi^2}{a\, r \log_e \frac{R}{r}}}$ (3)

where r is the thermal resistivity and a the electrical resistivity in ohms.

This shows that if the thickness of the insulating cover maintained a constant ratio to the diameter of the conductor, the limiting current strength would be directly proportional to the radius that is to the square foot of the cross-sectional area of the conductor. In that case doubling the diameter of the wire would quadruple its cross-section, but only double the carrying capacity. It is evident, however, from an examination of the dimension tables for any kind of electrical cable, that the thickness of insulator does not usually increase in proportion to the diameter of the wire, and consequently the carrying capacity will generally increase faster than the radius and slower than the cross-section. For the standard Siemens cables it appears that quadrupling the cross-section of the conductor increases the carrying capacity about three times.

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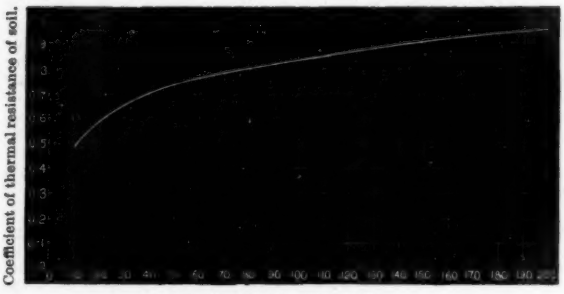
* Abstract of a paper read before the Association of Edison Illuminating Companies, Chicago, August 8th, 1893.

The case of buried cables differs from that of cables submerged only in the fact that the external surface of the sheathing is not maintained at the normal temperature of the environment. The ground in fact interposes an additional thermal resistance to the flow of heat from the active conductor. Assuming that the cable lies buried at a uniform depth below the level of surface of the ground, the thermal resistance of the soil will for a given external cable diameter depend only upon the depth and upon the thermal resistivity



Depth of axis in cable radii.

of the soil. On this assumption, then, the surfaces of heat flow are cylindrical, and the isothermal surfaces are also cylinders concentric to the conductor. The curve shown in the figure indicates the thermal coefficient of resistance of the soil as dependent upon the depth at which a cable lies buried. The ordinates represent the thermal coefficient or $\frac{S}{B}$; the abscissæ, the depth of cable axis below the surface of the soil in radii, the radius being that of the completed cable or last covering.

From this curve it appears that at a depth of 50 radii a quadruple increase, that is, to 200 radii only, changes the resistance per centimetre of length from 0·7339 to 0·9549, an increase of about 30 per cent. As regards the influence of duration of load upon temperature elevation, it would appear that under practical conditions, the temperature elevation in and near the cable tends to reach its maximum with comparative rapidity, the approximation to the final state being more tardy as the distance from the cable increases. In the measurements of the temperature elevation of buried samples, the elevation of sizes up to 200,000 circular mils (1,014 square cms.) appeared to attain 95 per cent. of their full value in the conductor within 20 minutes, and the increase became inappreciable after one hour. On the other hand, while a parallel idle cable 11·4 diameters horizontally distant reached 38 per cent. of the active cable's sheath temperature, in three hours, out of 42 per cent. calculated, another idle cable at 22·8 diameters appeared to reach only 17 per cent. out of a calculated 29 per cent. in the same period, a discrepancy that may well have been due to time lag. It may therefore be safe to infer that the conductor of a buried cable will closely approximate to its ultimate temperature elevation in one hour of steady load, but there can be little doubt that many hours will be needed to establish an equal approximation to the final state at a distance of, say, 40 diameters from the cable.

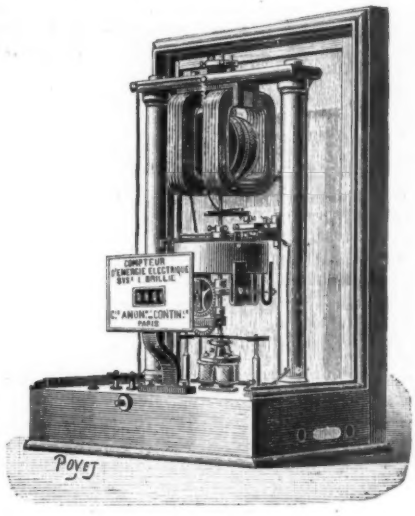
THE BRILLIÉ ELECTRICAL ENERGY METER.

NEW MODEL.

THE Continental Company working the Brillié patents has long endeavoured to simplify this meter (model 91), which we described in our number for April 29th, 1892, at the same time retaining its fundamental principle and all its advantages. The 1891 model, which is one of the most interesting types of electrical meters, is based upon an absolutely new and a very ingenious principle, combining all the requisite qualities of a good meter, correctness, proportionality, small consumption of current, certainty of starting, both for large and small outputs, extreme sensibility, and lastly, which is a most essential point, the indications of the instrument are not affected by variations of friction in the motive parts. We know, in fact, that in the Brillié meter the speed is regulated by the equilibrium of two forces, on the one hand, the effort in proportion to E I and exercised on the movable bobbin of the wattmetter, and on the other hand the effort exercised by the rotation of the magnets on a copper disc, an effort which is in proportion to the speed.

This model, however, still left something to be desired, although it did not affect the good working of the apparatus. It was somewhat complicated, in appearance, there were a great number of parts in motion, and lastly the speed of the motor was comparatively great. Monsieur S. Verneuil, engineer to the Continental Company, has endeavoured to improve and simplify the Brillié meter, and has fully succeeded.

The new model which we now take the opportunity of placing before our readers, and of which we show an engrav-



ing, whilst retaining the principles and the advantages enumerated above of the 1891 Brillié meter, may be justly considered as a great improvement and simplification in meters, and altogether an apparatus to be recommended from all points of view. The speed of the motor has been reduced, it now only makes 4 revolutions per second instead of 8 for the maximum output. The magnets are mounted directly on the same axle as the motor; thus the intermediate gearings are suppressed and the oiling and maintenance of the parts are also reduced. The meter works noiselessly, the starting and stopping are instantaneous, the sensibility is the same. The form of the new meter renders it more easy of transport and more reliable. The derivation terminal for the movable bobbin of the wattmeter has been suppressed and the two cables issue from the meter itself and return to it. The weight of the apparatus has been greatly reduced, 5 kilos instead of 13·5, and its size also. In addition to these advantages we may mention facility of standardising and maintenance, only one point requiring to be oiled, viz., the steel pivot of the motor which turns on a roller, also of steel, turning in a cup filled with oil. Scientifically speaking, we may say that the Brillié meter combines the highest number of advantages with the greatest simplicity.

In consequence of all these simplifications and improvements the price of the Brillié meters has been greatly reduced. Types have been made from 5 ampères up to 100, for 2, 3, or 5 wires, and for continuous or alternating currents.

The Continental Company, by whom these instruments are being constructed, have just made for the Sector of the Champs Elysées, Paris, three central station meters, for alternating currents, with a graphic register, for an E.M.F. of 3,000 volts and a current of 200 ampères.

We may mention that Messrs. Elliott Bros. are the agents in England for the Brillié meters.

NEW PATENTS—1893.

16,571. "Improvements in signal, telegraph, or other posts." I. A. TIMMIS. Dated September 4th.

16,594. "Improvements in electrical means of advertising." A. R. UPWARD. Dated September 4th.

16,597. "Improved inspissated oil for electrical insulating purposes, and method of producing same." A. GENTZSCH. Dated September 4th.

16,603. "Improved electric motor for punkahs." E. STUTZ. Dated September 4th.

16,630. "Improvements in obtaining zinc from solutions by electro-deposition." B. KITTO and W. MUIR. Dated September 4th.

16,699. "Improvements in electric cranes." W. PITT. Dated September 5th.

16,701. "Improvements in and relating to apparatus for the distribution and burning of fluid hydrocarbons for lighting and heating purposes." J. M. MCMURTRIE. Dated September 5th.

16,702. "Improvements in electro-coils for the administration of electricity to human beings, for medical purposes or others." E. S. D'ODIARDI and E. S. D'ODIARDI. Dated September 5th.

16,712. "An improvement in or connected with medico-electric bands." A. HALE. Dated September 5th.

16,746. "Improvements in the design and manufacture of polarisation plates for electric apparatus, and frames or holders for same." G. J. DAVIS. Dated September 6th.

16,770. "Improvements in electrical connections to floating vessels, balloons, buoys, and the like." G. M. HAMLYN. Dated September 6th.

16,825. "Improvements in the jointing or uniting of wires, rods, bars, or cables, more especially intended for jointing or uniting electric conductors." H. EDMUNDS. Dated September 7th.

16,836. "Improvements in or appertaining to incandescent electric lamps." W. P. THOMPSON. (Communicated by Otto Berndt, Germany.) Dated September 7th.

16,851. "Improved insulating material for electrical purposes and method of producing same." A. GENTZSCH. Dated September 7th.

16,880. "Improvements relating to the coating of plates, wire, and other metal articles by electro-deposition to protect the same from corrosion, and apparatus therefor." S. O. COWPER-COLES. Dated September 7th.

16,912. "Improvements in electric current meters." M. B. FIELD. Dated September 8th.

16,923. "Improvements in or relating to means or apparatus for preventing unauthorised persons overhearing private conversations by or through the telephone." C. E. PENISTON. Dated September 8th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1892.

2,722. "Improvements in electric switches." A. L. SHEPARD. Dated February 11th. Consists in arranging that the bar or bridge piece which makes contact shall be operated by means of a screwed spindle, and in the combination with the screwed spindle or with a nut on the said spindle of a spring or springs for effecting a quick break or quick make and break. 4 claims.

3,291. "Improvements in tubular electrical conductors." E. PAYNE. Dated February 19th. Consists in employing strips of metal bent into tubular form but without having their meeting edges united by soldering or otherwise, so that they have a certain elasticity. On a strip thus bent to tubular form are placed at intervals the non-conducting rings which, having their internal diameters somewhat less than the external diameter of the tubular strip, have to be pushed on with some force, and are held in position by the outward spring of the metal. 1 claim.

3,300. "Improved means for effecting the connection of electrical conductors." C. J. BARLEY. Dated February 19th. The inventor provides a socket which may be made of any suitable material, such as, for instance, copper. It has a pair of jaws of such size that they will receive between them the one conductor (say the main) and can then be hammered or pressed round or partly round the conductor. The said socket has also in it a hole or holes, or tubular piece or pieces, for receiving the second conductor or several such conductors (say the branch or branches). After the conductors have been received in the said socket a suitable metal, to make connection between the conductors and secure them together and in place in the socket, is introduced through an opening or openings provided for the purpose in the socket. 1 claim.

3,366. "Improvements in dynamo-electric machines." T. L. HEMMING. Dated February 20th. Consists in winding an armature with two wires so that the machine will be equal for all practical purposes to two separate machines, one for electric lighting and the other for the electro-deposition of metals. 1 claim.

3,801. "Improvements in electric bells." L. W. WINNALL and W. H. WINNALL. Dated February 26th. The motion of the armature is communicated to the hammer or clapper through the medium of a rack and pinion, the rack which is preferably of segmental shape being secured to the armature whilst the pinion is secured to the clapper in axial alignment with the axis upon which the clapper oscillates. 3 claims.

3,919. "Improved method of repairing incandescent electric lamps." W. S. RAWSON and WOODHOUSE & RAWSON UNITED, LTD. Dated February 29th. The inventors cut off the neck of the lamp at a suitable point between the shoulder and the loops or cap. When the separation has been effected, the leading in wires and broken filament are withdrawn with the upper part of the neck, and a new filament can then be easily attached to the wires by any of the well known methods. Subsequently the original, or if advisable, a new globe is joined to the neck by an ordinary fusion of the glass, care being taken to make the joint perfectly sound. The lamp is then ready to be exhausted in the ordinary way. 2 claims.

7,095. "Improvements in electric arc lamps." J. SUGDEN and W. J. L. SANDY. Dated April 13th. Consists in attaching to the upper carbon a plunger or piston, which is free to slide in a tube or cylinder, sealed, or partly sealed, in such a way that it retards any too sudden movement of the said plunger or piston. There is also a brake or catch which, in combination with an electro-magnet or magnets, acts directly on the carbons or rods carrying such carbons, and thus prevents their approaching each other until the pressure is released by the weakening of the said electro-magnet or magnets. 1 claim.

7,237. "Improvements in commutators for dynamo-electric machines and motors." B. S. PATERSON and J. B. FURNEAUX. Dated April 14th. Annular grooves are formed in the flange and ring on the commutator core or body between which the metal strips and insulating strips of the commutator are arranged; in the ends of the annulus of strips corresponding grooves are formed, and in these grooves are inserted keys made of mica. 2 claims.

11,779. "Improvements in the manufacture of carbons for electric arc lamps." C. BRAUN. Dated June 23rd. In this process the core-wick, previously made separately, is guided into the inside of a mandrel contained in a press, in such a manner that it only projects a little beyond this mandrel into the mass of carbon, and the carbon mass, spreading round the mandrel under the action of the plunger of the press, advances towards the outlet of the press, and takes at the same time a form corresponding with the conical shape of the point of the mandrel, forming a hollow body of constantly diminishing size, until having reached a point immediately in front of the point of the mandrel, it closely surrounds the core-wick which projects from the latter, and draws it with itself into the mouthpiece of the press in which the formation of the outer surface of the ensheathing carbon (that is to say, of the completed carbon) is finally effected. 4 claims.

12,506. "A new or improved telephone transmitter." R. H. JONES. Dated July 6th. Consists of two blocks of carbon placed horizontally one over the other and bridged across by a number of carbon rods, the ends of which may enter recesses in the said blocks. 4 claims.

14,813. "Improvements in electric battery plates." E. P. USHER. Dated August 16th. Relates to a battery plate having a marginal frame with open interior spaces, and one or more cross-bars spanning it, broad lateral surfaces of finely perforated lead foil adhering to and supported by said frame and cross-bars, and a filling of dry powdered oxide of lead packed into the enclosed spaces. 2 claims.

14,815. "Improvements in storage batteries." E. P. USHER. Dated August 16th. Relates to the sealing of the several plates and interposed separators at and near their lower edges, so as to hold the parts in the proper relation and prevent the contact with the negative plate of any of the active material which may crumble from the positive plate. This sealing is effected by erecting the plates and separators in a shallow body of gum, or the like, while in a hot and liquid state, and allowing it to cool and harden around and among the parts, or by applying plastic strips which harden and adhere to the edges of the plates and separators near the bottom. 4 claims.

16,262. "Improvements in the electrolytical decomposition of alkaline chlorides for the production of chlorine and alkalies, and in apparatus therefor." C. A. FAURE. Dated September 10th. Relates to improvements in the electrolytical decomposition of alkaline chlorides for the production of chlorine and alkali, and has for its chief object to avoid the production of a large quantity of hypochloric acid instead of chlorine, as frequently happens in electrolytical apparatus as heretofore constructed, and to enable the chlorine and alkali to be obtained in a pure, or practically pure, condition. 4 claims.

16,561. "Improvements in electric motors and dynamo-electric machines." A. W. MESTON. Dated September 16th. Has for its object, primarily, improvements in a motor of this character adapting it, first, to be automatically self-regulating under different loads; second, to be sensitively and positively self-starting from all possible positions of the armature, even under a load; third, to be reversed to run equally well in either direction, and, at the same time, be susceptible of being set to run at different speeds; and, fourth, to run for a comparatively long time without requiring attention. 63 claims.

20,611. "Improvements in governing electric motors." B. J. B. MILLS. (A communication from R. Lundell, of New York.) Dated November 15th. The inventor provides the dynamo-electric machine used as an electric motor with two or more independent coils or sections of coils upon its armature, and also two or more independent coils or section of coils upon its field magnet. This construction enables to be altered both the relation to each other in which the armature sections are connected, and also the relation to each other in which the field magnet sections are connected, and by doing this, the speed is changed by the change in the armature connections without varying the strength of the field magnet, and, therefore, without practically altering the torque. 6 claims.

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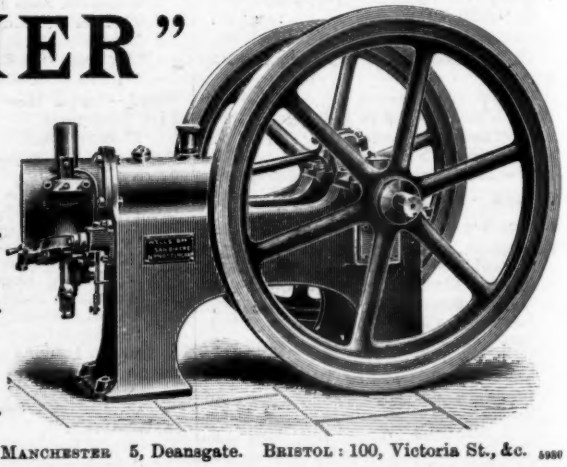

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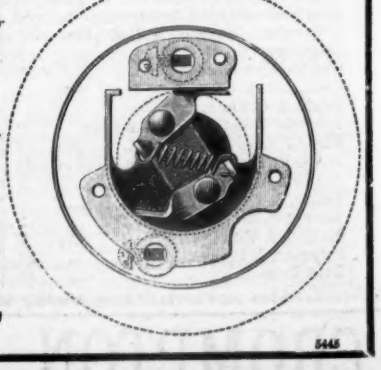

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